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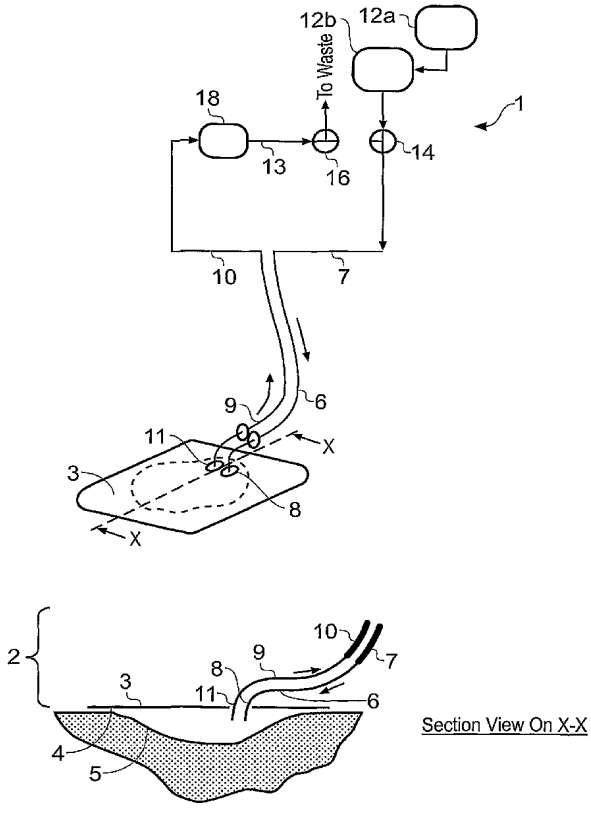

(57) Abstract: An apparatus for cleansing wounds in which irrigant fluid containing one or more physiologically active components from a means for supplying physiologically active agents from cells of tissue to the wound, *e.g.* an irrigant reservoir connected to a container that contains a cell or tissue component, in turn connected to a supply tube, connected to a conformable wound dressing and wound exudate from the dressing are moved by a device (which may be a single pump or two or more pumps) for moving fluid through a flow path which passes through the dressing and a means for providing simultaneous aspiration and irrigation of the wound. The latter removes materials deleterious to wound healing, while distributing materials that are beneficial in promoting wound healing from cells or tissue and the physiologically active components in therapeutically active amounts in a precise and time-controlled manner over the wound bed. The dressing, including one with openings that deliver the irrigant fluid directly to the wound bed over an extended area, and a method of treatment using the apparatus.

WO 2007/031762 A1

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APPARATUS WITH ACTIVES FROM TISSUE

The present invention relates to apparatus and a medical wound dressing for aspirating, irrigating and/or cleansing wounds, and a method of treating wounds using such apparatus for aspirating, irrigating and/or cleansing wounds.

It relates in particular to such an apparatus, wound dressing and method that can be easily applied to a wide variety of, but in particular chronic, wounds, to cleanse them of materials that are deleterious to wound healing, whilst distributing materials that are beneficial in some therapeutic aspect, in particular to wound healing.

Aspirating and/or irrigating apparatus are known, and tend to be used to remove wound exudate during wound therapy. In known forms of such wound therapy, aspiration and irrigation of the wound take place sequentially.

Each part of the therapy cycle is beneficial in promoting wound healing,

Aspiration applies a negative pressure to the wound, which is beneficial in itself in promoting wound healing by removing materials deleterious to wound healing, reducing bacterial load, combating peri-wound oedema and encouraging the formation of wound bed granulation tissue.

Irrigation cleanses wounds of materials that are deleterious to wound healing, by diluting and moving wound exudate (which is typically relatively little fluid and may be of relatively high viscosity and particulate-filled).

Additionally, relatively little of beneficial materials involved in promoting wound healing (such as cytokines, enzymes, growth factors, extracellular matrix components and fragments thereof, biological signalling molecules and other physiologically active components of the exudate) are present in a wound, and are not well distributed in the wound. That is, they are not necessarily present in parts of the wound bed where they can be potentially of most benefit. These may be distributed by irrigation of the wound and thus aid in promoting wound healing, using cells or tissue.

The irrigant may additionally contain active amounts of materials that are beneficial in promoting wound healing, which pass into and/or through the wound in contact with the wound bed.

If aspiration and irrigation therapy is applied sequentially to a wound, the two therapies, each of which is beneficial in promoting wound healing, can only be applied intermittently.

Thus, the wound will lose the abovementioned known beneficial effects of aspiration therapy on wound healing, at least in part, while that aspiration is suspended during irrigation.

Additionally, for a given aspirant flow, whilst materials that are potentially or actually deleterious in respect of wound healing are removed from wound exudate, the removal in a given time period of application of the total irrigate and/or aspirate therapy will normally be less effective and/or slower than with continuous application of aspiration.

Even less to be desired, is that while aspiration is not applied to the wound, wound exudate and materials deleterious to wound healing (such as bacteria and debris, and iron II and iron III and for chronic wounds proteases, such as serine proteases) will pool on the wound bed and hinder wound healing, especially in a highly exuding wound. This is especially the case in chronic wounds.

Depending on the relative volumes of irrigant and wound exudate, the mixed exudate-irrigant fluid and may be of relatively high viscosity and/or particulate-filled. Once it is present and has pooled, it may be more difficult to shift by the application of aspiration in a conventional sequential aspirate – irrigate – dwell cycle than with continuous simultaneous aspiration of the wound, owing to the viscosity and blockage in the system.

The wound will also lose the abovementioned beneficial effects of irrigation therapy on wound healing, at least in part, while that irrigation is suspended during aspiration.

These benefits in promoting wound healing include the movement of materials that are beneficial in promoting wound healing such as those mentioned above and the supply in the irrigant of active amounts of materials that are beneficial in promoting wound healing which pass into and/or through the wound in contact with the wound bed.

Additionally, for a given irrigant flow, cleansing of the wound and the distribution by irrigation of the wound of such beneficial materials and the supply in the irrigant of active amounts of materials that are beneficial in promoting wound healing in a given time period of application of the total irrigate and/or aspirate therapy when such therapy in a conventional sequential aspirate – irrigate – dwell cycle will normally be less effective and/or slower than with continuous application of aspiration.

Additionally, before the present invention, known aspirating and/or irrigating apparatus was not used for the delivery from cells or tissue of further materials that are beneficial in promoting wound healing. Examples of the latter include materials from cells or tissue, such as growth factors, extracellular matrix components and fragments thereof, selective proteases or fibrinolytic factors and combinations thereof.

Such known forms of aspiration and/or irrigation therapy systems also often create a wound environment that may result in the loss of optimum performance of the body's own tissue healing, using cells or tissue processes, and slow healing, using cells or tissue and/or in weak new tissue growth that does not have a strong three-dimensional structure adhering well to and growing from the wound bed. This is a significant disadvantage, in particular in chronic wounds.

The relevant devices tend not to be portable.

It thus would be desirable to provide a system of aspiration and irrigation therapy for a wound, which
can remove wound exudate and materials deleterious to wound healing, using cells or tissue from contact with the wound bed,
whilst simultaneously cleansing it and distributing materials that are beneficial in promoting wound healing from cells or tissue across it; and

supplying in the irrigant active amounts of materials that are beneficial in promoting wound healing, using cells or tissue which pass into and/or through the wound in contact with the wound bed.

It is an object of the present invention

a) to obviate at least some of the disadvantages of known aspiration and/or irrigation therapy systems, and
b) to provide a system of therapy which can remove materials deleterious to wound healing, using cells or tissue from wound exudate, whilst retaining materials that are beneficial in promoting wound healing, using cells or tissue in contact with the wound bed, and
c) further supplies fluids containing active amounts of materials that are beneficial in promoting wound healing from cells or tissue to pass into and/or through the wound in contact with the wound bed.

It is a yet further object of the present invention

a) to obviate at least some of the abovementioned disadvantages of known systems,
b) to provide a system of therapy which can remove materials deleterious to wound healing, whilst retaining materials that are beneficial in promoting wound healing, and adding such materials using cells or tissue to be, in contact with the wound bed, and
c) to provide a system that is portable.

Beneficial materials to be supplied to the wound may include, but not be limited to: growth factors, extracellular matrix components and fragments thereof, selective proteases or fibrinolytic factors and combinations thereof.

Vascular supply to, and aspiration in, tissue underlying and surrounding the wound is often compromised.

It is a further object of the present invention to provide a system of therapy that retains therapeutically active amounts of materials that are beneficial in reversing this effect and supplies such materials using cells or tissue, whilst removing deleterious materials, thereby promoting wound healing.

Thus, according to a first aspect of the present invention there is provided an apparatus for aspirating, irrigating and/or cleansing wounds, comprising

a) a fluid flow path, comprising
a conformable wound dressing, having
a backing layer which is capable of forming a relatively fluid-tight seal or closure over a wound and
at least one inlet pipe for connection to a fluid supply tube, which passes through and/or under the wound-facing face,
and at least one outlet pipe for connection to a fluid offtake tube, which passes through and/or under the wound-facing face,
the point at which the or each inlet pipe and the or each outlet pipe passes through and/or under the wound-facing face forming a relatively fluid-tight seal or closure over the wound;

b) at least one device for moving fluid through the wound dressing; and characterised in that it comprises

c) means for supplying physiologically active agents from cells or tissue to the wound, connected to a fluid supply tube;

d) means for providing simultaneous (or sequential) aspiration and irrigation of the wound,
such that the fluid containing such physiologically active agents from the cells or tissue may be supplied to fill the flowpath via the fluid supply tube from the means for supplying physiologically active agents from cells or tissue to the wound.

There is also provided an apparatus for aspirating, irrigating and/or cleansing wounds, comprising:

a) a fluid flow path comprising a wound dressing having a backing layer and at least one inlet pipe for connection to a fluid supply tube, which passes through and/or under the backing layer and at least one outlet pipe for connection to a fluid offtake tube, which passes through and/or under the backing layer;

b) at least one device for moving fluid through the wound dressing and characterised in that it comprises;

c) means for supplying physiologically active agents from cells or tissue to the wound, connected to a fluid supply tube;

d) means for providing sequential or simultaneous aspiration and irrigation of the wounds, such that the fluid containing such physiologically active

agents from the cells or tissue maybe supplied to fill the flow path via the fluid supply tube from the means for supplying physiologically active agents from cells or tissue to the wound.

Preferably any such apparatus is an automated, programmable system which can cleanse the wound irrigant and/or wound exudate with minimal supervision.

The present invention in this aspect provides several advantages.

One is that application of an irrigant to a wound under simultaneous aspiration creates a wound environment that is exposed to the continuous beneficial effects of both aspects of the therapy for wound healing, using cells or tissue, as opposed to the sequential intermittent application of irrigant flow and aspiration in known aspirating and/or irrigating apparatus.

The latter result in less than optimum performance of the body's own tissue healing, using cells or tissue processes, and slower healing, using cells or tissue and/or weaker tissue growth that does not have a strong three-dimensional structure adhering well to and growing from the wound bed. This is a significant disadvantage, in particular in chronic wounds.

Thus, the use of the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing wounds retains and enhances the beneficial effects of aspiration in respect of wound healing, using cells or tissue by continuous and preferably constant aspiration. These include removing materials deleterious to wound healing with the wound exudate, reducing bacterial load, combating peri-wound oedema and encouraging the formation of wound bed granulation tissue.

Preferred embodiments of the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing chronic wounds apply a milder negative pressure than in conventional negative pressure therapy (which is too aggressive for the fragile tissues of many such wounds). This leads to increased patient comfort, and lessens the risk of inflammation of the wound.

The removal of wound exudate in a given time period of application of the total irrigate and/or aspirate therapy will normally be more effective and/or faster than with a conventional sequential intermittent aspiration and/or irrigation therapy.

Even more desirably, since simultaneous aspiration and irrigation may be applied to the wound, wound exudate and materials deleterious to wound healing, using cells or tissue (such as bacteria and debris, and iron II and iron III and for chronic wounds proteases) will not pool on the wound bed and hinder wound healing, using cells or tissue, especially in a highly exuding wound. This is especially important in chronic wounds.

The resulting mixed exudate-irrigant fluid will usually be of relatively lower viscosity.

Because simultaneous aspiration and irrigation of the wound provides continuous removal at a constant relatively high speed, the fluid it does not have to be accelerated cyclically from rest, and will be easier to shift than with known forms of aspiration and/or irrigation therapy systems with a conventional sequential aspirate – irrigate – dwell cycle.

This will thus exert a greater net effect on the removal of adherent bacteria and debris.

This is especially the case in those embodiments of the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing wounds where there is an inlet manifold (as described in further detail hereinafter). This covers and contacts most of the wound bed with openings that deliver the fluid directly to the wound bed over an extended area.

This confers an advantage over the wound dressings in use before the present invention with means for supplying physiologically active agents under conventional sequential aspiration and irrigation of the wound.

In these, the physiologically active agents are often supplied to the wound bed through a foam, which acts as a baffle to reduce the rate of diffusion,

thus creating a concentration gradient of the physiologically active agents from a high concentration at the inlet point on the dressing to a low concentration at the wound bed.

It is therefore difficult to predict the concentration of actives at the wound bed. This effect is exacerbated by a counter-flow of exudate from the wound bed.

Many such dressings with means for supplying physiologically active agents to the wound bed also have a concentration gradient of the physiologically active agents across the wound bed from a high concentration at the inlet point to a low concentration at the outlet point.

It is therefore difficult to supply a uniform concentration of actives across the wound bed.

The inlet manifold in the wound dressings used in the present invention covers and contacts most of the wound bed with openings that deliver the fluid directly to the wound bed over an extended area, and therefore reduces the concentration gradient.

It is thus easy to predict the concentration of actives at the wound bed, and there tends to be no counter-flow of exudate from the wound bed. It is also easy to supply a uniform concentration of actives across the wound bed.

It will be seen that the balance of fluid between fluid aspirated from the wound and irrigant supplied to the wound may provide a predetermined steady state concentration equilibrium of materials beneficial in promoting wound healing, using cells or tissue over the wound bed. Simultaneous aspiration of wound fluid and irrigation at a controlled flow rate aids in the attainment and maintenance of this equilibrium

The present form of aspiration and/or irrigation therapy systems thus creates a wound environment for better distribution of materials that are beneficial in some therapeutic aspect, in particular to wound healing, using cells or tissue, that are present in a wound, but may not be well distributed in the wound, e.g. in a highly exuding wound.

(These include cytokines, enzymes, growth factors, extracellular matrix components and fragments thereof, biological signalling molecules and other physiologically active components of the exudate.) and/or materials in the irrigant that are potentially or actually beneficial in respect of wound healing, using cells or tissue, such as those noted below in this regard, e.g. growth factors and other physiologically active materials.

These may aid wound cell proliferation and new tissue growth that has a strong three-dimensional structure adhering well to and growing from the wound bed. This is a significant advantage, in particular in chronic wounds.

This is especially the case in those embodiments of the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing wounds where there is an inlet manifold as described above.

Simultaneous aspiration and irrigation of the wound provides advantages over topical bolus delivery, such as the pooled delivery of fluid to the wound bed by the application of a conventional sequential aspirate – irrigate – dwell cycle. These include (in addition to greater bioavailability to all areas of the wound surface as above), prolonged delivery between dressing changes and optimal dosing.

In the latter case, sequentially irrigating and aspirating a wound means the need to flood the wound with one or more static fluid physiologically active component in higher dosage concentration than is necessary to achieve a therapeutically active level of such actives on the wound bed.

This is just to maintain a desired average therapeutically active level of such actives on the wound bed during the dwell time period of sequentially irrigating and aspirating a wound, since these dosage concentrations levels tend to drop during this dwell time period in the cycle.

It will be seen that normally the level of such actives is effectively reduced to zero by the conventional sequential subsequent aspiration of the wound.

Less desirably, it has been observed that some of such physiologically active components, for example factors such as TGFβ show different

effects at high and low concentrations. An unnecessarily high dose to ensure activity during the residence between typical bolus applications in conventional sequential irrigation - aspiration of the wound may result in less than optimum dosing and performance of the body's own tissue healing, using cells or tissue processes.

Even less desirably, some of such physiologically active components may have adverse effects at higher concentrations.

An unnecessarily high dose to ensure activity during the residence between typical bolus applications in conventional sequential operation may result in undesirable effects on the wound bed.

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All of this may result in slow healing, using cells or tissue and/or slowing down of the healing, using cells or tissue and growth lacking a strong three-dimensional structure adhering well to and growing from the wound bed. This is a significant disadvantage, in particular in chronic wounds.

Some embodiments of the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing wounds with supply to the wound bed under a positive pressure may be advantageous.

Application of a positive pressure to the wound under the backing layer may make it possible to flood the tissue underlying the wound with one or more physiologically active components in therapeutically active amounts, to promote greater wound healing, using cells or tissue than by treatment with static fluid physiologically active component(s) alone or by sequential intermittent application of irrigant flow and aspiration

The prolonged delivery of such physiologically active components in therapeutically active amounts in a precise and time-controlled manner by simultaneous aspiration and irrigation, together with

a) the removal of materials deleterious to wound healing from the wound, and
b) the continuously supply of materials that are beneficial in promoting wound healing (that have been added using cells or tissue) to the wound bed,

promotes greater wound healing, using cells or tissue than

i) by treatment with the fluid physiologically active component(s) alone, or

ii) by topical bolus delivery in known aspirating and irrigating apparatus.

Advantages over topical bolus delivery include greater bioavailability to all areas of the wound surface, prolonged delivery between dressing changes and optimal dosing.

For example, factors such as TGFβ show different effects at high and low concentrations. Consequently, undesirable affects may be the result of an unnecessarily high dose to ensure prolonged residence between topical applications.

Supply to the wound bed under a positive pressure may be advantageous, as appplication of a positive pressure to the wound under the backing layer may make it possible to flood the tissue underlying the wound with one or more physiologically active components, added using cells or tissue, in therapeutically active amounts, to promote greater wound healing, than by treatment with physiologically active component(s) in static fluid alone.

Moving wound fluid aids in movement of biological signalling molecules involved in wound healing (including such materials that have been added using cells or tissue) to locations in the wound bed that are favourable to

a) wound healing and/or to

b) cells that would otherwise not be exposed to them, e.g. in a highly exuding wound.

This is especially the case in those embodiments of the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing wounds where there is an inlet manifold that delivers the fluid directly to the wound bed over an extended area.

Such materials include cytokines, enzymes, nutrients for wound cells to aid proliferation, oxygen, and other molecules that are beneficially involved in wound healing (including such materials that have been added using cells or tissue), such as growth factors, and others having beneficial effects (which may be further enhanced) in causing chemotaxis.

The apparatus for irrigating and/or aspirating wounds of the present invention may be used cyclically and/or with reversal of flow.

The means for supplying physiologically active agents from cells or tissue often conveniently comprises

a) an irrigant reservoir,
b) a container that contains a cell or tissue component, and
c) at least one supply tube for supplying physiologically active agents from cells or tissue and/or irrigant to the wound under the action of at least one device for moving fluid through the wound.

In one embodiment of the apparatus for irrigating, cleansing and/or aspirating wounds of the present invention, the means for supplying physiologically active agents from cells or tissue to the wound comprises

a) an irrigant reservoir connected to
b) a container that contains a cell or tissue component, in turn connected in series to
c) a supply tube for supplying physiologically active agents from cells or tissue and irrigant to the wound under the action of at least one device for moving fluid through the wound.

In use, irrigant is passed from the reservoir through the container that contains the cells or tissue and exits from it containing one or more physiologically active component materials that are beneficial in promoting wound healing that are expressed by the cells or tissue. The modified irrigant (including such physiologically active agents as have been added from the cells or tissue) is moved by a device for moving fluid through the supply tube and dressing to the wound. Then in admixture with wound exudate it is moved along the flow path, through the offtake tube.

In another embodiment of the apparatus for irrigating, cleansing and/or aspirating wounds of the present invention, the means for supplying physiologically active agents from cells or tissue to the wound comprises

a) an irrigant reservoir, and
b) a container that contains a cell or tissue component,

d) both connected in parallel to a supply tube for supplying physiologically active agents from cells or tissue and irrigant to the wound under the action of at least one device for moving fluid through the wound.

In this embodiment of the apparatus, the irrigant reservoir and the container that contains a cell or tissue component may be, e.g. connected to the supply tube by a Y-junction.
In use, irrigant is passed from the reservoir to the supply tube, and a fluid (which may be a nutrient medium for the cells or tissue) containing one or more physiologically active component materials that are beneficial in promoting wound healing that are expressed by the cells or tissue is passed from the container that contains the cells or tissue to the supply tube. The irrigant in admixture with such physiologically active agents as have been added from the cells or tissue is moved by a device for moving fluid through the wound to and through the wound.

In yet another embodiment of the apparatus for irrigating, cleansing and/or aspirating wounds of the present invention, the means for supplying physiologically active agents from cells or tissue to the wound comprises

a) an irrigant reservoir, connected to
b) a first supply tube for supplying irrigant to the wound under the action of at least one device for moving fluid through the wound, and
c) a container that contains a cell or tissue component, connected to
d) a second supply tube for supplying physiologically active agents from the cells or tissue the wound dressing.

In use, irrigant is passed from the reservoir to the first supply tube for supplying irrigant to the wound. The fluid containing one or more physiologically active component materials that are beneficial in promoting wound healing that are expressed by the cells or tissue is passed from the container that contains the cells or tissue to the second supply tube for supplying physiologically active agents from the cells or tissue the wound dressing. Each is moved by a device for moving fluid through the wound to and through the wound. The irrigant is admixed in the wound space with the physiologically active agents that have been added from the cells or tissue.

In a further embodiment of the apparatus for irrigating, cleansing and/or aspirating wounds of the present invention, the means for supplying physiologically active agents from cells or tissue to the wound comprises

a) an irrigant reservoir connected to

b) a container that contains a cell or tissue component, under the backing layer, and which communicates with the wound via at least one channel or conduit for supplying physiologically active agents from cells or tissue and irrigant to the wound under the action of at least one device for moving fluid through the wound.

The container that contains a cell or tissue component may be integral with the other components of the dressing, in particular the backing layer. Alternatively, it may be permanently or demountably attached to them/it, with an adhesive film, for example, or by heat-sealing.

In use, irrigant is passed from the reservoir through the container that contains the cells or tissue and exits from it into the wound space under the backing layer proximal face containing one or more physiologically active component materials that are beneficial in promoting wound healing that are expressed by the cells or tissue.

In yet a further embodiment of the apparatus for irrigating, cleansing and/or aspirating wounds of the present invention, the means for supplying physiologically active agents from cells or tissue to the wound comprises

a) a first irrigant reservoir connected to

b) a supply tube for supplying irrigant to the wound under the action of at least one device for moving fluid through the wound, and

c) a second irrigant reservoir connected to

d) a container that contains a cell or tissue component, under the backing layer, and which communicates with the wound via at least one channel or conduit for supplying physiologically active agents from cells or tissue and irrigant to the wound under the action of at least one device for moving fluid through the wound.

The container that contains a cell or tissue component may be integral with the other components of the dressing, in particular the backing layer.

Alternatively, it may be permanently or demountably attached to them/it, with an adhesive film, for example, or by heat-sealing.

In use, irrigant is passed from the first reservoir to the supply tube for supplying irrigant to the wound. Irrigant is also passed from the second reservoir to the container.

The fluid containing one or more physiologically active component materials that are beneficial in promoting wound healing that are expressed by the cells or tissue is passed from the container that contains the cells or tissue to the second supply tube for supplying physiologically active agents from the cells or tissue the wound dressing. Each is moved by a device for moving fluid through the wound to and through the wound.

The irrigant is admixed in the wound space with the modified irrigant containing physiologically active agents that have been added from the cells or tissue.

All of these embodiments of the means for supplying physiologically active agents from cells or tissue to the wound may use cells or tissues of two or more different types. In such systems, a first input cell or tissue type is often contained in a first container, and a second input cell or tissue type is often contained in a second container.

The two input cell or tissue types and containers may feed physiologically active agents in parallel to the dressing and to the wound bed under the action of at least one device for moving fluid through the wound.

In this embodiment of the apparatus, the containers that contain the cell or tissue components may be, e.g. connected to a single supply tube by a Y-junction, and thence to the wound dressing, or they may, e.g. be connected to it by separate supply tubes, the two flows of physiologically active agents from cells or tissue optionally with irrigant and/or nutrient medium for the cells being optionally mutually admixed in the wound space under the wound dressing.

In an alternative layout of this means for supplying physiologically active agents from cells or tissue to the wound, the first container, in which the first input cell or tissue type is contained, is in fluid communication in series with the second container, in which the second cell or tissue type is contained.

Thus, they feed their physiologically active agents in series to the dressing and to the wound bed under the action of at least one device for moving fluid through the wound. In this layout of the means for supplying physiologically active agents from cells or tissue, the two containers effectively function as a single container.

As noted above, irrigant and/or nutrient medium for the cells or tissue is often fed through the containers of the cell or tissue components and thence to the wound dressing. In use, these layouts of the means for supplying physiologically active agents from cells or tissue to the wound will function in the apparatus exactly as for their analogues with a single cell or tissue type.

The container that contains a cell or tissue component is often in the form of a hollow body such as an e.g. a canister, cartridge or cassette. It often has a chamber or compartment that contains a cell or tissue component, through which irrigant and/or a nutrient medium for the cells or tissue is passed.

Where the container that contains a cell or tissue component lies outside the backing layer, the structure will often be made of glass, and/or synthetic polymeric materials. For example, such a structure may be a glass cylinder defining a chamber with axial inlet and outlet ports for throughflow, which contains cells or tissue on a scaffold.

Where the container that contains a cell or tissue component lies under the backing layer, the structure will often be made of a conformable synthetic polymeric material.

Such a structure may still be a structure defining a chamber with an inlet port, which contains cells or tissue on a scaffold, and which communicates with the wound via at least one channel or conduit.

The latter is/are for supplying physiologically active agents from cells or tissue and irrigant to the wound under the action of at least one device for moving fluid through the wound.

Where the container that contains a cell or tissue component is integral with the other components of the dressing, in particular the backing layer, it will usually be of the same polymeric material as the components. Where, alternatively, it is permanently or demountably attached to them/it, with an adhesive film, for example, or by heat-sealing, it may be of a different polymeric material.

Any such structure may contain a cell or tissue component that is not bound to an insoluble and immobilised substrate over and/or through which the irrigant and/or wound exudate from the wound dressing passes.

It then also appropriately comprises two or more integers which are permeable to the wound exudate or a mixture with irrigant, but have apertures, holes, openings, orifices, slits or pores of sufficiently small cross-dimension to hold the cell or tissue component, and to retain particulates, e.g. cell debris, in the hollow body. Each of the integers may then effectively form a macroscopic and/or microscopic filter.

Alternatively, it may contain a cell or tissue component that is bound to an insoluble and immobilised substrate over and/or through which the irrigant and/or wound exudate from the wound dressing passes, e.g. a scaffold.

This will often be of a material that is not (cyto)toxic and is biocompatible and inert to any components that are beneficial in promoting wound healing, including natural and synthetic polymeric materials, which may typically in the form of a conformable film, sheet or membrane, often with apertures, holes, openings, orifices, slits or slots of small cross-dimension. It may then effectively form a structure which is a mesh, grid, lattice, net or web.

The container for cells or tissue may then not need to comprise two or more integers which are permeable to the wound exudate or a mixture with

irrigant to hold the cell or tissue component in the hollow body, but they may be desirable to retain particulates, e.g. cell debris.

The container that contains the tissue or cell component will normally be mounted within or in association with a device constructed to maintain the viability and activity of the cells. This would include but not be limited to the means for supplying nutrition and regulating the exchange of gases and maintaining an optimum temperature.

The means for supplying nutrition may comprise a conventional nutrient medium for the cells or tissue containing one or more physiologically active component materials that are beneficial in promoting cell proliferation in the cells or tissue in the container that contains the cells or tissue and/or the expression by such cells or tissue of one or more physiologically active component materials that are beneficial in promoting wound healing.

To achieve therapeutically effective amounts of materials that are beneficial in promoting wound healing, a fluid flow though and/or over the cells or tissue may have to be maintained over multiple cycles, with significant dwell times and/or over significant periods of time.

Thus, in those embodiments of the means for supplying physiologically active agents from cells or tissue to the wound described above, the container that contains a cell or tissue component may be provided with

a) means for recycling nutrient medium for the cells or tissue from and back to a nutrient medium reservoir, e.g. a loop comprising the reservoir, connected to the container that contains the cells or tissue, with a pump, and in particular
b) means for switching fluid flow between recycling around the loop comprising the reservoir and the container and supply to the relevant supply tube.

Such means for switching fluid flow may comprise at least one one-way valve in the loop and in the fluid supply tube, or a two way valve connecting the supply tube and the loop.

In use, nutrient medium for the cells or tissue is recycled from and back to a nutrient medium reservoir in the loop comprising the reservoir and the

container that contains the cells or tissue, with a pump, over multiple cycles, with significant dwell times and/or over significant periods of time until the cell proliferation in the cells or tissue in the container that contains the cells or tissue and/or the expression by such cells or tissue of one or more physiologically active component materials that are beneficial in promoting wound healing have achieved the desired levels.

Recycling nutrient medium for the cells or tissue from and back to the nutrient medium reservoir is then stopped, and supply to the relevant supply tube is started.

This may be achieved by stopping the pump and/or closing a one-way valve in the loop and opening on in the supply tube, or by switching a two way valve connecting the supply tube and the loop.

The necessary desired levels of physiologically active component materials, valves, pumps, number of cycles, dwell times and/or time periods will be apparent to the skilled person.

As noted above, in another embodiment of the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing wounds, a particular advantage is that the means for supplying physiologically active agents from cells or tissue to the wound lies within the wound dressing.

In use, irrigant is passed from the reservoir through the cells or tissue component for supplying physiologically active agents to the wound which lies within the wound dressing, and exits from it containing one or more component physiologically active component materials that are beneficial in promoting wound healing that are expressed by the cells or tissue. The modified irrigant (including such physiologically active agents as have been added from the cells or tissue) in admixture with wound exudate is moved by the device for moving fluid through the offtake tube along the flow path.

Thus, one embodiment of the apparatus for irrigating, cleansing and/or aspirating wounds of the present invention is characterised in that it the

means for supplying physiologically active agents from cells or tissue to the wound comprises

a) an irrigant reservoir fluidically connected to

b) a wound dressing that contains a cell or tissue component.

The wound dressing backing layer, which is capable of forming a relatively fluid-tight seal or closure over a wound, and the wound bed define a wound space, which contains cells or tissue. As noted above for a separate container, the wound space may contain a cell or tissue component that is not bound to an insoluble and immobilised substrate over and/or through which the irrigant and/or wound exudate from the wound passes.

It then also appropriately comprises two or more integers which are permeable to the wound exudate or a mixture with irrigant, but have apertures, holes, openings, orifices, slits or pores of sufficiently small cross-dimension to hold the cell or tissue component, and to retain particulates, e.g. cell debris, in the hollow body.

Each of the integers may then effectively form a macroscopic and/or microscopic filter.

Alternatively, it may contain a cell or tissue component that is bound to an insoluble and immobilised substrate over and/or through which the irrigant and/or wound exudate from the wound passes, e.g. a scaffold.

This will often be of a material, and may typically be in the form, noted above as amongst those that are suitable for such components of a separate container that contains a cell or tissue component.

The wound space may contain a cell or tissue component at any appropriate point in contact with the irrigant and/or wound exudate, and the component may be as appropriate, adhered or otherwise secured to any integer of the wound dressing, e.g. the dressing backing layer or a wound filler, or it may be a separate structures, permanently unattached.

It may often lie in contact with the wound bed. Where it does so, it may be advantageous if it is

a) bound to an insoluble and immobilised substrate over and/or through which the irrigant and/or wound exudate from the wound passes, or
b) not bound to an insoluble and immobilised substrate, but comprised in two or more integers which are permeable to the wound exudate or a mixture with irrigant, and
c) comprises a biodegradable mesh, grid, lattice, net or web, with apertures, holes, openings, orifices, slits or pores of small cross-dimension in contact with the wound bed.

The cell or tissue component in contact with continuously supplied and recirculated irrigant and/or wound exudate has the ability to add elements beneficial to wound healing to the irrigant, but the same elements also aid proliferation of wound bed cells into the apertures, holes, openings, orifices, slits or pores of small cross-dimension of the biodegradable mesh, grid, lattice, net or web, which is also beneficial to wound healing.

In general, the tissue component has the ability to elaborate or express materials beneficial to wound healing to the irrigant to modify the irrigant.

As described in further detail hereinafter, such elements beneficial to wound healing may be biochemical, e.g. enzymatic or physical antagonists to elements detrimental to wound healing in the exudate and/or exudate and irrigant.

An additional embodiment of the apparatus for irrigating, cleansing and/or aspirating wounds of the present invention is characterised in that the physiologically active components that have been added using cells or tissue in amounts to promote wound healing comprise materials that are beneficial in promoting wound healing by removing materials or by regulating, limiting or inhibiting processes deleterious to wound healing.

Depending on the particular type of wound being treated and the particular cells or tissue used in the present apparatus for aspirating, irrigating and/or cleansing wounds, the deleterious materials to be removed may include proteases, such as serine proteases, e.g. elastase and thrombin; cysteine proteases; matrix metalloproteases, e.g. collagenase; and carboxyl (acid) proteases;

inhibitors of angiogenesis such as thrombospondin-1 (TSP-1), Plasminogen activator inhibitor, or angiostatin (plasminogen fragment)
pro-inflammatory cytokines such as tumour necrosis factor alpha (TNFα) and interleukin 1 beta (IL-1β), and
inflammatories, such as lipopolysaccharides, and e.g. histamine.

Again, depending on the particular type of wound being treated and the particular cells or tissue used in the present apparatus for aspirating, irrigating and/or cleansing wounds, the beneficial materials to be added may include antagonists to the materials deleterious to wound healing in the wound exudate, such as, for example
enzymes or others, such as protease inhibitors, such as serine protease inhibitors, cysteine protease inhibitors; matrix metalloprotease inhibitors; and carboxyl (acid) protease inhibitors;
binders and/or degraders, such as anti-inflammatory materials to bind or destroy lipopolysaccharides, e.g. peptidomimetics;

They further include peptides (including cytokines, e.g. bacterial cytokines, such as α-amino-γ-butyrolactone and L-homocarnosine); and
other physiologically active components.

Examples of antagonists to such materials also include
natural proteins or recombinant-produced protein, proteinase inhibitors, such as tissue inhibitors of metalloproteinases (TIMP 1 to 4) and alpha 1-antitrypsin (AAT), aprotinin, α-2-macroglogulin;
antibodies or other molecules at inappropriate levels that inhibit or inactivate processes or materials deleterious to wound healing, such as matrix metalloproteinases (MMPs), neutrophil elastase, inhibitors of new blood vessel formation (angiogenesis) such as thrombospondin or kallistatin and combinations thereof.

The irrigant may alternatively or additionally, where appropriate, deliver a steady supply of natural proteins or recombinant-produced protein debriding agents to remove and limit eschar, necrotic cells and tissues from the wound bed.

Examples of such include stretoptokinase, plasmin, trypsin, collagenases, and other selective proteases or fibrinolytic factors and combinations thereof.

The irrigant supplied to the wound dressing may alternatively or additionally, where appropriate, contain materials added using cells or tissue such as
antioxidants, such as ascorbic acid or stable derivatives thereof and
free radical scavengers, such as gutathione or natural proteins or recombinant-produced proteins such as superoxide dismutase (SOD), or
free radical generators to balance the oxidative stress and oxidant potential of the wound bed in order to maximise the opportunity for wound healing.

The active material may act beneficially on the wound bed and have the ability to aid wound healing, as it is passed by the device through the flow path, through biochemical, enzymatic or physical means without any such role as a biochemical, enzymatic or physical antagonist.

Examples of such components (however supplied) also include:
autologous, allogeneic or xenogeneic blood or blood products, such as platelet lysates, plasma or serum.
natural proteins or recombinant-produced protein growth factors, such as platelet derived growth factor (PDGF), vascular endothelial growth factor (VEGF), transforming growth factor alpha (TGFα) or transforming growth factor beta (TGFβ-1, 2 or 3), basic-fibroblast growth factor (b-FGF also known as FGF2), epidermal growth factor (EGF), granulocyte-macrophage colony-stimulating factor (GM-CSF); insulin like growth factor-1 (IGF-1) and keratinocyte growth factor 2 KGF2 (also known as FGF7);
natural purified proteins or recombinant produced protein cytokines such as the interleukin 1β (IL1β), or interleukin 8 (IL-8) and
other physiologically active agents whether present normally in acute or chronic wounds, that can be augmented in the irrigant fluid to be of benefit to the wound bed, when such therapy is applied, and combinations thereof.

The irrigant supplied to the wound dressing may alternatively or additionally, where appropriate, contain materials added using cells or tissue such as nutrients for wound cells to aid proliferation or migration or

the synthesis of matrix components or factors beneficial to wound healing, such as sugars, amino acids, purines, pyrimidines, vitamins, metal ions or minerals.

The irrigant supplied to the wound dressing on the wound bed may alternatively or additionally, where appropriate supply materials to achieve the delivery of nucleic acid molecules as active genes or gene-containing vectors (DNA, RNA or modified versions thereof), as
naked molecules,
molecules complexed with nucleic acid binding carriers,
molecules within liposomes or
as virus vectors to give steady, measured delivery of gene therapeutic molecules to wound bed cells.

In the means for supplying physiologically active agents from cells or tissue to the wound, the irrigant from the reservoir that passes into and through the cell or tissue component often conveniently comprises cell culture medium species.

Examples of the latter include
trace elements and/or other nutrients such as amino acids, sugars, low molecular weight tissue building blocks, purines, pyrimidines, vitamins, metal ions or minerals, and/or
gases, such as air, nitrogen, oxygen and/or nitric oxide,
to aid proliferation of the cells or tissue in the means and/or steady, measured expression and supply of physiologically active agents.

In such case, materials that are listed above are also suitable therapeutic molecules to supply to wound bed cells to aid proliferation of the cells or tissue, and/or which are otherwise beneficial to wound healing.

In such case, it may be desirable to provide a system in which the irrigant from the reservoir that passes into and through the cell or tissue component comprises cell culture medium species and thereafter is supplied to the wound bed via a supply tube into the flowpath wherever appropriate, so that such cell culture medium species pass with the irrigant to the wound bed.

The irrigant from the reservoir may be used to maintain an optimum temperature of the cells or tissue and/or for regulating the exchange of gases in a conventional manner apparent to the skilled person. It is necessary for such a system to also irrigate the wound at a practical rate with the physiologically active components in therapeutically active amounts.

Automated, programmable systems which can regulate the wound irrigant parameters and functions listed above in a precise and time-controlled manner are amongst those that are particularly suitable for use.

The tissue component may be an ex vivo (autologous, allogeneic or xenogenic) uncultured tissue explant.

Alternatively the tissue component may be formed from separated or partially separated cells which have either been used without a period of culture or they may have been cultured in vitro. The process of culture may involve growth and proliferation or just incubation in culture.

The source tissues may be tissue from any organ such as skin, muscle, bone, neural, connective tissue, intestinal, liver or amniotic tissue and other organs or combinations thereof, whose cells and tissue retain the appropriate properties.

The cells or tissue may be fully viable or viable, but rendered non-dividing through irradiation or chemical treatment, or rendered non-viable after an appropriate period of culture.

Alternatively, the cells or tissue may be genetically modified to increase production of a particular material, e.g. a protein that is beneficial in promoting wound healing, such as a growth factor, an extracellular matrix component or fragments thereof, and other physiologically active components, or a biochemical, e.g. enzymatic or physical antagonists to elements detrimental to wound healing in the exudate and/or exudate and irrigant.

The tissue component that provides the active material that acts beneficially on the wound bed may consist of a co-culture. A co-culture encompasses the in vitro or ex vivo culture of two or more cell types or tissue explants. This might be with one or both input cells or tissues fully viable or viable, but rendered non-dividing, through irradiation or chemical treatment, or rendered non-viable after an appropriate period of culture. Alternatively, the cells or tissue may be genetically modified to increase production of a particular material, e.g. a protein that is beneficial in promoting wound healing, such as a growth factor, an extracellular matrix component or fragments thereof, and other physiologically active components, or a biochemical, e.g. enzymatic or physical antagonists to elements detrimental to wound healing in the exudate and/or irrigant.

The input cells or tissues may be intimately mixed or intermingled, or they may be present as layers one on the other.

In some systems a semi permeable membrane or matrix between the component cells or tissues allows communication through biochemicals or proteins or other signals, but no cell apposition between the input cell types. In further systems modified irrigant is collected from one input cell or tissue type and given to the second input cell or type and given back to the first input cell type (sequentially or continuously) to generate the optimal output.

The cell or tissue component may be activated either singly or repeatedly through the delivery of biochemical, protein, enzymatic or physical means or through electromagnetic irradiation, ultrasonic or electrical stimulation.

Preferably the present apparatus for aspirating, irrigating and/or cleansing wounds is a conventionally automated, programmable system which can cleanse the wound with minimal supervision.

The means for providing simultaneous aspiration and irrigation of the wound often comprises
a (first) device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, in combination with at least one of

a second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing;
means for supply flow regulation, connected to a fluid supply tube;
means for aspirate flow regulation, connected to a fluid offtake tube, and

The (first) device is applied to the fluid in the fluid tube and/or the fluid in the fluid offtake tube downstream of and away from the wound dressing, and will usually apply negative pressure (i.e. below-atmospheric pressure or vacuum) to the wound bed.

The (first) device for moving fluid through the wound will often be a pump of any of the following types, or a piped supply of vacuum, applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing.

It may have means for aspirate flow regulation, such as a regulator, such as a rotary valve connected between two parts of a fluid offtake tube, such that the desired supply flow regulation is achieved.

The following types of pump may be used as the (first) device:
reciprocating pumps, such as piston pumps - where pistons pump fluids through check valves, in particular for positive and/or negative pressure on the wound bed; and
diaphragm pumps - where pulsations of one or two flexible diaphragms displace liquid with check valves.
and
rotary pumps, such as:
progressing cavity pumps - with a cooperating screw rotor and stator, in particular for higher-viscosity and particulate-filled exudate; and
vacuum pumps - with pressure regulators.

The (first) device may be a diaphragm pump, e.g. preferably a small portable diaphragm pump. This is a preferred type of pump, in order in particular to reduce or eliminate contact of internal surfaces and moving parts of the pump with (chronic) wound exudate, and for ease of cleaning.

Where the pump is a diaphragm pump, and preferably a small portable diaphragm pump, the one or two flexible diaphragms that displace liquid may each be, for example a polymer film, sheet or membrane, that is connected to means for creating the pulsations. This may be provided in any form that is convenient, inter alia as a piezoelectric transducer, a core of a solenoid or a ferromagnetic integer and coil in which the direction of current flow alternates, a rotary cam and follower, and so on.

Where any second device is applied to the fluid in the fluid supply tube upstream of and towards the wound dressing, it will usually apply positive pressure (i.e. above-atmospheric pressure) to the wound bed.

The second device for moving fluid through the wound will often be a pump of any of the following types applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing.

It may have means for aspirate flow regulation, such as a regulator, such as a rotary valve connected between two parts of a fluid offtake tube, such that the desired supply flow regulation is achieved.

The following types of pump may be used as the second device:

reciprocating pumps, such as

shuttle pumps - with an oscillating shuttle mechanism to move fluids at rates from 2 to 50 ml per minute

and

rotary pumps, such as:

centrifugal pumps

flexible impeller pumps - where elastomeric impeller traps fluid between impeller blades and a moulded housing that sweeps fluid through the pump housing.

peristaltic pumps - with peripheral rollers on rotor arms acting on a flexible fluid aspiration tube to urge fluid current flow in the tube in the direction of the rotor.

rotary vane pumps - with rotating vaned disk attached to a drive shaft moving fluid without pulsation as it spins. The outlet can be restricted without damaging the pump.

The second device may be a peristaltic pump, e.g. preferably a small portable peristaltic pump. This is a preferred type of pump, in order in particular to reduce or eliminate contact of internal surfaces and moving parts of the pump with irrigant, and for ease of cleaning.

Where the pump is a peristaltic pump, this maybe e.g. an Instech Model P720 miniature peristaltic pump, with a flow rate: of 0.2 – 180ml/hr and a weight of < 0.5 k. This is potentially useful for home and field hospital use.

Each such pump of any these types may also suitably be one that is capable of pulsed, continuous, variable and/or automated and/or programmable fluid movement. Less usually and less preferably, each such pump of any these types will be reversible.

The means for supply flow regulation maybe a regulator, such as a rotary valve. This is connected between two parts of a fluid supply tube, such that the desired supply flow regulation is achieved.

If there are two or more inlet pipes, these maybe connected to a single fluid supply tube with a single regulator, or to first, second, etc. fluid supply tubes, respectively having a first regulator, a second regulator, etc., e.g. a valve or other control device for admitting fluids into the wound.

The means for aspirate flow regulation may be similarly provided in a form in which concomitant aspirate flow regulation is possible. It may be a regulator, such as a valve or other control device, e.g. a rotary valve.

Multiple offtake tubes maybe similarly provided with single or multiple regulators, all for aspiration of fluids from the apparatus, e.g. to a waste reservoir, such as a collection bag.

If there is no second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing, it is only possible to apply a negative pressure to the wound, by means of the device for moving fluid through the wound applied to the

aspirate in the fluid offtake tube downstream of and away from the wound dressing.

Operation may e.g. be carried out at a negative pressure of up to 50%atm., typically at a low negative pressure of up to 20% atm., more usually up to 10% atm. at the wound, as is described hereinafter.

Examples of suitable and preferred (first) devices include those types of pump that are so described hereinbefore in relation to the first device. This may be a diaphragm pump, e.g. preferably a small portable diaphragm pump. This is a preferred type of pump, in order in particular to reduce or eliminate contact of internal surfaces and moving parts of the pump with (chronic) wound exudate, and for ease of cleaning.

Alternatively, if it is desired to apply a positive pressure to the wound, the means for providing simultaneous aspiration and irrigation of the wound must comprise not only
a first device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, but also
a second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing.

Operation may then e.g. be carried out at a positive pressure of up to 50%atm., typically at a low positive pressure of up to 20% atm., more usually up to 10% atm. at the wound, as is described hereinafter.

Examples of suitable and preferred first devices include those types of pump that are so described hereinbefore in relation to the first device. This may be a diaphragm pump, e.g. preferably a small portable diaphragm pump.

This is a preferred type of pump, in order in particular to reduce or eliminate contact of internal surfaces and moving parts of the pump with (chronic) wound exudate, and for ease of cleaning.

Examples of suitable and preferred second devices include those types of pump that are so described hereinbefore in relation to the second device. This may be a peristaltic pump, e.g. a miniature peristaltic pump. This is a preferred type of pump, in order to eliminate contact of internal surfaces and moving parts of the pump with irrigant in the fluid supply tube upstream of and towards the wound dressing, and for ease of cleaning.

It is of course equally possible to apply a negative pressure to the wound, by means of such a combination of
a first device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, and
a second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing;
optionally with
means for supply flow regulation, connected to a fluid supply tube;
means for aspirate flow regulation, connected to a fluid offtake tube.

Indeed, as noted below in this regard, preferred embodiments of the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing chronic wounds that apply a negative pressure include such types of combination of
a first device, e.g. a diaphragm pump, e.g. preferably a small portable diaphragm pump, and
a second device, e.g. a peristaltic pump, preferably a miniature peristaltic pump,
as described hereinbefore in relation to the device for moving fluid through the wound.

The higher end of these ranges of % pressures and/or vacua are potentially more suitable for hospital use, where relatively high % pressures and/or vacua may be used safely under professional supervision.

The lower end is potentially more suitable for home use, where relatively high % pressures and/or vacua cannot be used safely without professional supervision, or for field hospital use.

In each case, the pressure on the wound may be held constant throughout the desired length of therapy, or may be varied cyclically in a desired positive or negative pressure regime.

As noted above, when it is desired to apply a negative pressure to the wound, it is preferred that the means for providing simultaneous aspiration and irrigation of the wound comprise not only
a (first) device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, but also
a second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing.

Accordingly, one embodiment of the apparatus for irrigating, cleansing and/or aspirating wounds of the present invention is characterised in the means for providing simultaneous aspiration and irrigation of the wound comprises
a (first) device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, and
a second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing, and
in combination with at least one of
means for supply flow regulation, connected to a fluid supply tube, and
means for aspirate flow regulation, connected to a fluid offtake tube.

This combination of

a) a device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, and
b) a device for moving fluid through the wound applied to the fluid in the fluid supply tube upstream of and towards the wound dressing,

may be used to apply an overall positive or negative, or even neutral pressure to the wound.

At least one body in the flow path to, over and from the wound bed should have sufficient resilience against the pressure to allow any significant compression or decompression of the fluid occur.

Thus, examples of suitable bodies include those which are or are defined by a film, sheet or membrane.

These include inlet or offtake and/or tubes and structures such as bags, chambers and pouches, filled with irrigant fluid, and e.g. the backing layer of the wound dressing, made of elastically resilient thermoplastic materials.

It will be seen that the balance of fluid between aspirated fluid from the wound and irrigant supplied to the wound from the fluid means for supplying physiologically active agents from cells or tissue to the wound, e.g. from

a) an irrigant reservoir connected to
b) a container that contains a cell or tissue component, in turn connected to a supply tube,

will thus be largely determined by a means for providing simultaneous aspiration and irrigation of the wound which is a system comprising:

i) means for aspirate flow regulation and/or a device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, and
ii) means for supply flow regulation and/or a device for moving fluid through the wound applied to the fluid in the fluid supply tube upstream of and towards the wound dressing,

The same means may be used to apply an overall positive or negative, or even neutral pressure to the wound.

The appropriate flow rate through the supply tube will depend on a number of factors, such as
the components of the irrigant and/or wound exudate, the relative volumes of irrigant and wound exudate, the viscosity and consistency of each of the irrigant, exudate and mixed exudate-irrigant fluid, and any changes as the wound heals;
the level of negative pressure on the wound bed, and

whether the irrigant in the fluid supply tube upstream of and into the wound dressing is under positive pressure, and the level of such pressure;
the depth and/or capacity of the wound and
the power consumption needed for a given desired fluid volume flow rate of irrigant and/or wound exudate through the wound.

It may also depend on the level of any pressure drop between the irrigant in the fluid supply tube upstream of the wound dressing and the wound bed, such as across a porous element, e.g. a membrane wound contact layer on the lower surface of an inlet manifold that delivers the fluid directly to the wound bed; means for supply flow regulation; and/or a second device for moving fluid through the wound applied to the fluid in the fluid supply tube upstream of and towards the wound dressing;

The dressing may comprise an inlet manifold (as described in further detail hereinafter) that covers and contacts most of the wound bed with openings that deliver the fluid directly to the wound bed over an extended area. This may be in the form of one or more inflatable hollow bodies defined by a film sheet or membrane.

The (usually small) positive pressure above atmospheric in the manifold from the irrigation device when both devices are running together should be sufficient to inflate the manifold.

The desired fluid volume flow rate of irrigant and/or wound exudate is preferably that for optimum performance of the wound healing process.

The flow rate with any will usually be in the range of 1 to 1500 ml/hr, such as 5 to 1000 ml/hr, e.g. 15 to 300 ml/hr, such as 35 to 200 ml/hr through the supply tube. The flow rate through the wound may be held constant throughout the desired length of therapy, or may be varied cyclically in a desired flow rate regime.

In practice, the offtake rate of flow of total irrigant and/or wound exudate will be of the order of 1 to 2000, e.g. 35 to 300 ml/24 hr/cm^2, where the cm^2 refers to the wound area, depending on whether the wound is in a highly exuding state.

In practice, the rate of exudate flow is only of the order of up to 75 microlitres / cm^2/ hr (where cm^2 refers to the wound area), and the fluid can be highly mobile or not, depending on the level of proteases present). Exudate levels drop and consistency changes as the wound heals, e.g. to a level for the same wound that equates to 12.5 – 25 microlitres / cm^2 / hr.

It will be seen that the aspirated fluid from the wound will typically contain a preponderance of modified irrigant from the means for supplying physiologically active agents from cells or tissue to the wound over wound exudate

The necessary adjustments to maintain the desired balance of fluid by means of

a) the means for aspirate flow regulation and/or downstream device, and
b) the means for supply flow regulation and/or upstream device for moving fluid

will be apparent to the skilled person.

The type and/or capacity of
a suitable first device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing and/or
a suitable second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing and/or
will be largely determined by

a) the appropriate or desired fluid volume flow rate of irrigant and/or wound exudate from the wound, and
b) whether it is appropriate or desired to apply a positive or negative pressure to the wound bed, and the level of such pressure to the wound bed

for optimum performance of the wound healing process, and by factors such as portability, power consumption and isolation from contamination.

As noted above, it may be desired to apply a negative pressure to the wound with the apparatus of this first aspect of the present invention, whilst providing simultaneous aspiration and irrigation of the wound.
In such a case, the means for providing simultaneous aspiration and irrigation of the wound may comprise
a single device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing or in combination with at least one of
means for supply flow regulation, connected to a fluid supply tube, and
means for aspirate flow regulation, connected to a fluid offtake tube.

The operation of a typical apparatus for simultaneous aspiration and irrigation of a wound at a low negative pressure of up to 20% atm., more usually up to 10% atm. at the wound, with one pump will now be described.

That is, an apparatus with
a single device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, in combination with
means for supply flow regulation, connected to a fluid supply tube, and
means for aspirate flow regulation, connected to a fluid offtake tube.

Before starting the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing wounds, the backing layer of the wound dressing is applied over the wound and conformed to the shape of the bodily part in which the wound is to form a relatively fluid-tight seal or closure.

The means for supply flow regulation, connected to a fluid supply tube, such as a regulator, such as a rotary valve, is usually closed, and the means for aspirate flow regulation, connected to a fluid offtake tube, is opened.

The aspiration pump is started and run to give a negative pressure of up to 50% atm., more usually up to 20% atm. to be applied applies a vacuum to the interior of the dressing and the wound.

The means for fluid supply regulation is then adjusted to maintain the desired balance of fluid at a controlled nominal flow rate.
The apparatus is then run for the desired length of therapy and with the desired negative pressure regime.

After this period, the aspiration pump is stopped.

The operation of a typical apparatus for simultaneous aspiration and irrigation of a wound at a low negative pressure of up to 20% atm., more usually up to 10% atm. at the wound, with two pumps will now be described.

The necessary changes where the mode of operation is at a positive pressure of e.g. up to 15% atm., more usually up to 5% atm. at the wound will be apparent to the skilled person.

Such a typical apparatus for simultaneous aspiration and irrigation of a wound will operate at a low negative pressure of up to 20% atm., more usually up to 10% atm. at the wound.

It comprises means for providing simultaneous aspiration and irrigation of the wound which is a combination of

a) a first device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, with optional means for aspirate flow regulation, connected to a fluid offtake tube: and
b) a second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing, with optional means for supply flow regulation, connected to a fluid supply tube.

Before starting the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing wounds, the backing layer of the wound dressing is applied over the wound and conformed to the shape of the bodily part in which the wound is to form a relatively fluid-tight seal or closure.

Any means for supply flow regulation, connected to a fluid supply tube, such as a regulator, such as a rotary valve, is usually closed, and any means for aspirate flow regulation, connected to a fluid offtake tube, is opened.

The aspiration pump is started and run to give a negative pressure of up to 50% atm., more usually up to 20% atm. to be applied applies a vacuum to the interior of the dressing and the wound.
The irrigation pump is then started, so that both pumps are running together, and any means for supply flow regulation is opened.

The irrigation pump flow rate and any means for fluid supply regulation are then adjusted to maintain the desired balance of fluid at a controlled nominal flow rate.

The apparatus is then run for the desired length of therapy and with the desired positive or negative pressure regime.

After this period, the irrigation pump is stopped, shortly followed by the aspiration pump.

In all embodiments of the apparatus of this first aspect of the present invention for aspirating, irrigating and/or cleansing wounds, a particular advantage is the tendency of the wound dressing to conform to the shape of the bodily part to which it is applied.

The wound dressing comprises a backing layer with a wound-facing face which is capable of forming a relatively fluid-tight seal or closure over a wound and
at least one inlet pipe for connection to a fluid supply tube or tube, which passes through and/or under the wound-facing face, and
and at least one outlet pipe for connection to a fluid offtake tube, which passes through and/or under the wound-facing face,
the point at which the or each inlet pipe and the or each outlet pipe passes through and/or under the wound-facing face forming a relatively fluid-tight seal or closure.

The term 'relatively fluid-tight seal or closure' is used herein to indicate one which is fluid- and microbe-impermeable and permits a positive or negative pressure of up to 50% atm., more usually up to 20% atm. to be applied to the wound. The term 'fluid' is used herein to include gels, e.g. thick exudate, liquids, e.g. water, and gases, such as air, nitrogen, etc.

The shape of the backing layer that is applied may be any that is appropriate to aspirating, irrigating and/or cleansing the wound across the area of the wound.

Examples of such include a substantially flat film, sheet or membrane, or a bag, chamber, pouch or other structure of the backing layer, e.g. of polymer film, which can contain the fluid.

The backing layer may be a film, sheet or membrane, often with a (generally uniform) thickness of up to 100 micron, preferably up to 50 micron, more preferably up to 25 micron, and of 10 micron minimum thickness.

Its largest cross-dimension may be up to 500 mm (for example for large torso wounds), up to 100 mm (for example for axillary and inguinal wounds), and up to 200 mm for limb wounds (for example for chronic wounds, such as venous leg ulcers and diabetic foot ulcers.

Desirably the dressing is resiliently deformable, since this may result in increased patient comfort, and lessen the risk of inflammation of a wound.

Suitable materials for it include synthetic polymeric materials that do not absorb aqueous fluids, such as polyolefins, such as polyethylene e.g. high-density polyethylene, polypropylene, copolymers thereof, for example with vinyl acetate and polyvinyl alcohol, and mixtures thereof; polysiloxanes; polyesters, such as polycarbonates; polyamides, e.g. 6-6 and 6 - 10, and hydrophobic polyurethanes.

They may be hydrophilic, and thus also include hydrophilic polyurethanes.

They also include thermoplastic elastomers and elastomer blends, for example copolymers, such as ethyl vinyl acetate, optionally or as necessary blended with high-impact polystyrene.

They further include elastomeric polyurethane, particularly polyurethane formed by solution casting.
Preferred materials for the present wound dressing include thermoplastic elastomers and curable systems.

The backing layer is capable of forming a relatively fluid-tight seal or closure over the wound and/or around the inlet and outlet pipe(s). The backing layer maybe impermeable, semi-impermeable or otherwise.

However, in particular around the periphery of the wound dressing, outside the relatively fluid-tight seal, it is preferably of a material that has a high moisture vapour permeability, to prevent maceration of the skin around the wound. It may also be a switchable material that has a higher moisture vapour permeability when in contact with liquids, e.g. water, blood or wound exudate. This may, e.g. be a material that is used in Smith & Nephew's Allevyn™, IV3000™ and OpSite™ dressings.

The periphery of the wound-facing face of the backing layer may bear an adhesive film, for example, to attach it to the skin around the wound.

This may, e.g. be a pressure-sensitive adhesive, if that is sufficient to hold the wound dressing in place in a fluid-tight seal around the periphery of the wound-facing face of the wound dressing.

Alternatively or additionally, where appropriate a light switchable adhesive could be used to secure the dressing in place to prevent leakage.
(A light switchable adhesive is one the adhesion of which is reduced by photocuring. Its use can be beneficial in reducing the trauma of removal of the dressing.)

Thus, the backing layer may have a flange or lip extending around the proximal face of the backing layer, of a transparent or translucent material

(for which it will be understood that materials that are listed above are amongst those that are suitable).

This bears a film of a light switchable adhesive to secure the dressing in place to prevent leakage on its proximal face, and a layer of opaque material on its distal face. To remove the dressing and not cause excessive trauma in removal of the dressing, the layer of opaque material on the distal face of the flange or lip extending around the proximal wound is removed prior to application of radiation of an appropriate wavelength to the flange or lip.

If the periphery of the wound dressing, outside the relatively fluid-tight seal, that bears an adhesive film to attach it to the skin around the wound, is of a material that has a high moisture vapour permeability or is a switchable material, then the adhesive film, if continuous, should also have a high or switchable moisture vapour permeability, e.g. be an adhesive such as used in Smith & Nephew's Allevyn™, IV3000™ and OpSite™ dressings.

Where a vacuum, is applied to hold the wound dressing in place in a fluid-tight seal around the periphery of the wound-facing face of the wound dressing, the wound dressing may be provided with a silicone flange or lip to seal the dressing around the wound. This removes the need for adhesives and associated trauma to the patient's skin.

Where the interior of, and the flow of irrigant and/or wound exudate to and through, the dressing is under any significant positive pressure, which will tend to act at peripheral points to lift and remove the dressing off the skin around the wound.

In such use of the apparatus, it may thus be necessary to provide means for forming and maintaining such a seal or closure over the wound against such positive pressure on the wound, to act at peripheral points for this purpose.

Examples of such means include light switchable adhesives, as above, to secure the dressing in place to prevent leakage.

Since the adhesion of a light switchable adhesive is reduced by photocuring, thereby reducing the trauma of removal of the dressing, a film of a more aggressive adhesive may be used, e.g. on a flange, as above.

Examples of suitable fluid adhesives for use in more extreme conditions where trauma to the patient's skin is tolerable include ones that consist essentially of cyanoacrylate and like tissue adhesives, applied around the edges of the wound and/or the proximal face of the backing layer of the wound dressing, e.g. on a flange or lip.

Further suitable examples of such means include adhesive (e.g. with pressure-sensitive adhesive) and non-adhesive, and elastic and non-elastic straps, bands, loops, strips, ties, bandages, e.g. compression bandages, sheets, covers, sleeves, jackets, sheathes, wraps, stockings and hose, e.g. elastic tubular hose or elastic tubular stockings that are a compressive fit over a limb wound to apply suitable pressure to it when the therapy is applied in this way; and inflatable cuffs, sleeves, jackets, trousers, sheathes, wraps, stockings and hose that are a compressive fit over a limb wound to apply suitable pressure to it when the therapy is applied in this way.

Such means may each be laid out over the wound dressing to extend beyond the periphery of the backing layer of the wound dressing, and as appropriate will be adhered or otherwise secured to the skin around the wound and/or itself and as appropriate will apply compression (e.g. with elastic bandages, stockings) to a degree that is sufficient to hold the wound dressing in place in a fluid-tight seal around the periphery of the wound,

Such means may each be integral with the other components of the dressing, in particular the backing layer.

Alternatively, it may be permanently attached or releasably attached to the dressing, in particular the backing layer, with an adhesive film, for example, or these components may be a Velcro ™, push snap or twist-lock fit with each other.

The means and the dressing may be separate structures, permanently unattached to each other.

In a more suitable layout for higher positive pressures on the wound, a stiff flange or lip extends around the periphery of the proximal face of the backing layer of the wound dressing as hereinbefore defined.

The flange or lip is concave on its proximal face to define a peripheral channel or conduit.

It has a suction outlet that passes through the flange or lip to communicate with the channel or conduit and may be connected to a device for applying a vacuum, such as a pump or a piped supply of vacuum.

The backing layer may be integral with or attached, for example by heat-sealing, to the flange or lip extending around its proximal face.

To form the relatively fluid-tight seal or closure over a wound that is needed and to prevent passage of irrigant and/or exudate under the periphery of the wound-facing face of the wound dressing, in use of the apparatus, the dressing is set on the skin around the wound.

The device then applies a vacuum to the interior of the flange or lip, thus forming and maintaining a seal or closure acting at peripheral points around the wound against the positive pressure on the wound.

With all the foregoing means of attachment, and means for forming and maintaining a seal or closure over the wound, against positive or negative pressure on the wound at peripheral points around the wound, the wound dressing sealing periphery is preferably of a generally round shape, such as an ellipse, and in particular circular.

To form the relatively fluid-tight seal or closure over a wound and around the inlet pipe(s) and outlet pipe(s) at the point at which they pass through and/or under the wound-facing face, the backing layer may be integral with these other components.

The components may alternatively just be a push, snap or twist-lock fit with each other, or adhered or heat-sealed together.

The or each inlet pipe or outlet pipe may be in the form of an aperture, such as a funnel, hole, opening, orifice, luer, slot or port for connection as a female member respectively to a mating end of
a fluid tube and/or fluid supply tube (optionally or as necessary via means for forming a tube, pipe or hose, or nozzle, hole, opening, orifice, luer, slot or port for connection as a male member respectively to a mating end of
a fluid tube and/or fluid supply tube (optionally or as necessary via means for supply flow regulation) or
a fluid offtake tube.

Where the components are integral they will usually be made of the same material (for which it will be understood that materials that are listed above are amongst those that are suitable).

Where, alternatively, they are a push, snap or twist-lock fit, the may be of the same material or of different materials. In either case, materials that are listed above are amongst those that are suitable for all the components.

The or each pipe may pass through, rather than under the backing layer. In such case, the backing layer may often have a rigid and/or resiliently inflexible or stiff area to resist any substantial play between the or each pipe and the or each mating tube, or deformation under pressure in any direction. It may often be stiffened, reinforced or otherwise strengthened by a boss projecting distally (outwardly from the wound) around each relevant tube, pipe or hose, or nozzle, hole, opening, orifice, luer, slot or port for connection to a mating end of a fluid tube and/or fluid supply tube or fluid offtake tube.

Alternatively or additionally, where appropriate the backing layer may have a stiff flange or lip extending around the proximal face of the backing layer to stiffen, reinforce or otherwise strengthen the backing layer.

The wound dressing may not comprise any integer under the backing layer in the wound in use.

However, this may not provide a system to distribute irrigant over a sufficient functional surface area to irrigate the wound at a practical rate to be suitable for use, in particular in chronic wound aspiration and irrigation, with relatively high concentrations of materials that are deleterious to wound healing.

It may be advantageous to provide a system where wound irrigant may be distributed more evenly, or pass in a more convoluted path under the dressing over the wound bed.

Accordingly, one form of the dressing is provided with a 'tree' form of pipes, tubes or tubules that radiate from an inlet manifold to the wound bed to end in apertures and deliver the aspirating fluid directly to the wound bed via the apertures. Similarly, there is an outlet manifold from which tubules radiate and run to the wound bed to end in openings and collect the fluid directly from the wound bed.

The pipes, etc. may radiate regularly or irregularly through the wound in use, respectively from the inlet or outlet manifold, although regularly may be preferred. A more suitable layout for deeper wounds is one in which the pipes, etc. radiate hemispherically and concentrically, to the wound bed.

For shallower wounds, examples of suitable forms of such layout of the pipes, etc. include ones in which the pipes, etc. radiate in a flattened hemiellipsoid and concentrically, to the wound bed.

Other suitable forms of layout of the pipes, etc. include one which have pipes, tubes or tubules extending from the inlet pipe(s) and/or outlet pipe(s) at the point at which they pass through and/or under the wound-facing face of the backing layer to run over the wound bed. These may have a blind bore with perforations, apertures, holes, openings, orifices, slits or slots along the pipes, etc.

These pipes, etc. then effectively form an inlet pipe manifold that delivers the aspirating fluid directly to the wound bed or outlet pipe or collects the fluid directly from the wound respectively.

It does so via the holes, openings, orifices, slits or slots in the tubes, pipes, tubules, etc. over most of the wound bed under the backing layer.

It may be desirable that the tubes, pipes or tubules are resiliently flexible, e.g. elastomeric, and preferably soft, structures with good conformability in the wound and the interior of the wound dressing.

When the therapy is applied in this way, the layout of the tubes, pipes, tubules, etc. may depend on the depth and/or capacity of the wound.

Thus, for shallower wounds, examples of suitable forms of such layout of the tubes, pipes, tubules, etc. include ones that consist essentially of one or more of the tubes, etc in a spiral.

A more suitable layout for deeper wounds when the therapy is applied in this way may be one which comprises one or more of the tubes, etc in a helix or spiral helix.

Other suitable layouts for shallower wounds include one which have blind-bore, perforated inlet pipe or outlet pipe manifolds that aspirate fluid in the wound when the dressing is in use.
One or both of these may be such a form, the other may be, e.g. one or more straight blind-bore, perforated radial tubes, pipes or nozzles.

A preferred form of inlet pipe (or less usually) outlet pipe manifold that delivers the aspirating fluid directly to the wound bed or collects the fluid directly from the wound respectively is one that comprise one or more conformable hollow bodies defined by a film, sheet or membrane, such as a bag, chamber, pouch or other structure, filled with the irrigant (or less usually) aspirate from the wound, passing through perforations, apertures, holes, openings, orifices, slits or slots in the film, sheet or membrane defining the hollow body or hollow bodies.

These may be of small cross-dimension, so that they may then effectively form microperforations, microapertures or pores in a permeable integer, for example the polymer film, sheet or membrane.

This type of manifold for irrigation (more usually) provides the highest uniformity in the flow distribution of irrigant over the wound at a practical rate to be suitable for use, in particular in chronic wound aspiration and irrigation, and hence to provide a system where materials that are beneficial in promoting wound healing from cells or tissue, such as growth factors, extracellular matrix components and fragments thereof, and other physiologically active components, are distributed more evenly under the dressing over the wound bed.

This type of manifold for irrigation (more usually) is noted below with regard to wound fillers under the backing layer, since it is a resiliently flexible, e.g. elastomeric, and soft, structure with good conformability to wound shape that is urged by its own resilience against the backing layer to apply gentle pressure on the wound bed, and is therefore also capable of acting as a wound filler. The film, sheet or membrane, often has a (generally uniform) thickness similar to that of films or sheets used in conventional wound dressing backing layers.

Another suitable layout is one in which
an inlet pipe and/or outlet pipe manifold that delivers the aspirating fluid directly to the wound bed or collects the fluid directly from the wound respectively
via inlet and/or outlet tubes, pipes or tubules,
and the inlet manifold and/or outlet manifold is formed by slots in layers permanently attached to each other in a stack, and
the inlet and/or outlet tubes, pipes or tubules are formed by apertures through layers permanently attached to each other in a stack. (In Figure 10a there is shown an exploded isometric view of such a stack, which is non-limiting.)

As also mentioned herein, the backing layer that is applied may be any that is appropriate to the present system of therapy and permits a positive or negative pressure of up to 50% atm., more usually up to 25% atm. to be applied to the wound.

It is thus often a microbe-impermeable film, sheet or membrane, which is substantially flat, depending on any pressure differential on it.

It often has a (generally uniform) thickness similar to such films or sheets used in conventional wound dressings, i.e. up to 100 micron, preferably up to 50 micron, more preferably up to 25 micron, and of 10 micron minimum thickness.

The backing layer may often have a rigid and/or resiliently inflexible or stiff area to resist any substantial play between other components that are not mutually integral, and may be stiffened, reinforced or otherwise strengthened, e.g. by a projecting boss.

Such a form of dressing would not be very conformable to the wound bed, and may effectively form a chamber, hollow or cavity defined by a backing layer and the wound bed under the backing layer.

It may be desirable that the interior of the wound dressing conform to the wound bed, even for a wound in a highly exuding state. Accordingly, one form of the dressing is provided with a wound filler under the backing layer. This is favourably a resiliently flexible, e.g. elastomeric, and preferably soft, structure with good conformability to wound shape.

It is urged by its own resilience against the backing layer to apply gentle pressure on the wound bed.

The wound filler may be integral with the other components of the dressing, in particular the backing layer.

Alternatively, it may be permanently attached to them/it, with an adhesive film, for example, or by heat-sealing, e.g. to a flange or lip extending from the proximal face, so a not to disrupt the relatively fluid-tight seal or closure over the wound that is needed.

Less usually, the wound filler is releasably attached to the backing layer, with an adhesive film, for example, or these components may be a push, snap or twist-lock fit with each other.

The wound filler and the backing layer may be separate structures, permanently unattached to each other.

The wound filler may be or comprise a solid integer, favourably a resiliently flexible, e.g. elastomeric, and preferably soft, structure with good conformability to wound shape.

Examples of suitable forms of such wound fillers are foams formed of a suitable material, e.g. a resilient thermoplastic. Preferred materials for the present wound dressing include reticulated filtration polyurethane foams with small apertures or pores.

Alternatively or additionally, it may be in the form of, or comprise one or more conformable hollow bodies defined by a film, sheet or membrane, such as a bag, chamber, pouch or other structure, filled with a fluid or solid that urges it to the wound shape.

The film, sheet or membrane, often has a (generally uniform) thickness similar to that of films or sheets used in conventional wound dressing backing layers.

That is, up to 100 micron, preferably up to 50 micron, more preferably up to 25 micron, and of 10 micron minimum thickness, and is often resiliently flexible, e.g. elastomeric, and preferably soft.

Such a filler is often integral with the other components of the dressing, in particular the backing layer, or permanently attached to them/it, with an adhesive film, for example, or by heat-sealing, e.g. to a flange

Examples of suitable fluids contained in the hollow body or bodies defined by a film, sheet or membrane include gases, such as air, nitrogen and argon, more usually air, at a small positive pressure above atmospheric; and liquids, such as water, saline.

Examples also include gels, such as silicone gels, e.g. CaviCare™ gel, or preferably cellulosic gels, for example hydrophilic cross-linked cellulosic gels, such as Intrasite ™ cross-linked materials. Examples also include

aerosol foams, where the gaseous phase of the aerosol system is air or an inert gas, such as nitrogen or argon, more usually air, at a small positive pressure above atmospheric; and solid particulates, such as plastics crumbs.

Of course, if the backing layer is a sufficiently conformable and/or e.g. an upwardly dished sheet, the backing layer may lie under the wound filler, rather than vice versa.

In this type of layout, in order for the wound filler to urge the wound dressing towards the wound bed, it will usually have to be firmly adhered or otherwise releasably attached to the skin around the wound. This is especially the case in those embodiments where the wound filler and the backing layer are separate structures, permanently unattached to each other.

In such a layout for deeper wounds when the therapy is applied in this way, the means for such attachment may also form and maintain a seal or closure over the wound.

Where the filler is over the backing layer, and the fluid inlet pipe(s) and outlet pipe(s) pass through the wound-facing face of the backing layer, they may run through or around the wound filler over the backing layer.

One form of the dressing is provided with a wound filler under the backing layer that is or comprises a resiliently flexible, e.g. elastomeric, and preferably soft, hollow body defined by a film, sheet or membrane, such as a bag, chamber, pouch or other structure.
It has apertures, holes, openings, orifices, slits or slots, or tubes, pipes, tubules or nozzles. It communicates with at least one inlet or outlet pipe through at least one aperture, hole, opening, orifice, slit or slot.

The fluid contained in the hollow body may then be the aspirating fluid in the apparatus.

The hollow body or each of the hollow bodies then effectively forms an inlet pipe or outlet pipe manifold that delivers the aspirating fluid directly to the

wound bed or collects the fluid directly from the wound respectively via the holes, openings, orifices, slits or slots, or the tubes, pipes or hoses, etc. in the film, sheet or membrane.

When the therapy is applied in this way, the type of the filler may also be largely determined by the depth and/or capacity of the wound.

Thus, for shallower wounds, examples of suitable wound fillers as a component of a wound dressing include ones that consist essentially of one or more conformable hollow bodies defining an inlet pipe and/or outlet pipe manifold that delivers the aspirating fluid directly to the wound bed or collects the fluid directly from the wound.

A more suitable wound filler for deeper wounds when the therapy is applied in this way may be one which comprises one or more conformable hollow bodies defined by, for example a polymer film, sheet or membrane, that at least partly surround(s) a solid integer. This may provide a system with better rigidity for convenient handling.

Unless the wound filler under the backing layer effectively forms an inlet pipe or outlet pipe manifold, in order for aspiration and/or irrigation of the wound bed to occur, it is appropriate for one or more bores, channels, conduits, passages, pipes, tubes, tubules and/or spaces, etc. to run from the point at which the fluid inlet pipe(s) and outlet pipe(s) pass through and/or under the wound-facing face of the backing layer through or around the wound filler under the backing layer.

Less usually, the wound filler is an open-cell foam with pores that may form such bores, channels, conduits, passages and/or spaces through the wound filler under the backing layer.

Where the filler is or comprises one or more conformable hollow bodies defined by, for example a polymer film, sheet or membrane, it may be provided with means for admitting fluids to the wound bed under the wound dressing.

These may be in the form of pipes, tubes, tubules or nozzles running from the point at which the fluid inlet pipe(s) and outlet pipe(s) pass through and/or under the wound-facing face of the backing layer through or around the wound filler under the backing layer.

All of the suitable layouts for shallower wounds that comprise blind-bore, perforated inlet pipe or outlet pipe manifolds that aspirate fluid in the wound when the dressing is in use, that are described hereinbefore, may be used under a wound filler under the backing layer.

In brief, suitable layouts include ones where one or both manifolds are annular or toroidal (regular, e.g. elliptical or circular or irregular), optionally with blind-bore, perforated radial tubes, pipes or nozzles, branching from the annulus or torus; and/or
in a meandering, tortuous, winding, zigzag, serpentine or boustrophedic (i.e. in the manner of a ploughed furrow) pattern, or
defined by slots in and apertures through layers attached to each other in a stack.

The inlet and/or outlet tubes, the fluid tube and the fluid supply tube, etc. may be of conventional type, e.g. of elliptical or circular cross-section, and may suitably have a uniform cylindrical bore, channel, conduit or passage throughout their length, and suitably the largest cross-dimension of the bore may be up to 10 mm for large torso wounds, and up to 2 mm for limb wounds.

The tube walls should suitably thick enough to withstand any positive or negative pressure on them. However, the prime purpose of such tubes is to convey fluid irrigant and exudate through the length of the apparatus flow path, rather than to act as pressure vessels. The tube walls may suitably be at least 25 micron thick.

The bore or any perforations, apertures, holes, openings, orifices, slits or slots along the pipes, etc. or in the hollow body or each of the hollow bodies may be of small cross-dimension.

They may then effectively form a macroscopic and/or microscopic filter for particulates including cell debris and micro-organisms, whilst allowing proteins and nutrients to pass through.

Such tubes, pipes or hoses, etc. through and/or around the filler, whether the latter is a solid integer and/or one or more resiliently flexible or conformable hollow bodies, are described in further detail hereinbefore in connection with the inlet pipe(s) and outlet pipe(s).

The whole length of the apparatus for aspirating, irrigating and/or cleansing wounds should be microbe-impermeable once the wound dressing is over the wound in use.

It is desirable that the wound dressing and the interior of the apparatus for aspirating, irrigating and/or cleansing wounds of the present invention is sterile.

The fluid may be sterilised in the fluid reservoir and/or the rest of the system in which the fluid moves by ultraviolet, gamma or electron beam irradiation (except for the integer that contains the tissue or cell component, since this may adversely affect the viability and activity of the cells). This way, in particular reduces or eliminates contact of internal surfaces and the fluid with any sterilising agent.

Examples of other methods of sterilisation of the fluid also include e.g. the use of

ultrafiltration through microapertures or micropores, e.g. of 0.22 to 0.45 micron maximum cross-dimension, to be selectively impermeable to microbes; and

fluid antiseptics, such as solutions of chemicals, such as chlorhexidine and povidone iodine; metal ion sources, such as silver salts, e.g. silver nitrate; and hydrogen peroxide;

although the latter involve contact of internal surfaces and the fluid with the sterilising agent.

It may be desirable that the interior of the wound dressing, the rest of the system in which the fluid moves, and/or the wound bed, even for a wound

in a highly exuding state, are kept sterile after the fluid is sterilised in the fluid reservoir, or that at least naturally occurring microbial growth is inhibited.

Thus, materials that are potentially or actually beneficial in this respect may be added to the irrigant initially, and as desired the amount in increased by continuing addition.

Examples of such materials include antibacterial agents (some of which are listed above), and antifungal agents.

Amongst those that are suitable are, for example triclosan, iodine, metronidazole, cetrimide, chlorhexidine acetate, sodium undecylenate, chlorhexidine and iodine.

Buffering agents, such as potassium dihydrogen phosphate/ disodium hydrogen phosphate. may be added to adjust the pH, as may local analgesics/anaesthetics, such as lidocaine/lignocaine hydrochloride, xylocaine (adrenoline, lidocaine) and/or anti-inflammatories, to reduce wound pain or inflammation or pain associated with the dressing.

In order to combat the deposition of materials in the flow path from the irrigant, a repellent coating may be used at any point or on any integer in the path in direct contact with the fluid. This may be, e.g. on the means for providing simultaneous aspiration and irrigation of the wound or any desired tube or pipe.

Examples of coating materials for surfaces over which the aspirating fluid passes include
anticoagulants, such as heparin, and
high surface tension materials, such as PTFE, and polyamides,
which are useful for growth factors, enzymes and other proteins and derivatives.

The apparatus of the invention for aspirating, irrigating and/or cleansing wounds is provided with means for admitting fluids directly or indirectly to

the wound under the wound dressing in the form of a fluid supply tube to a fluid reservoir.

The fluid reservoir may be of any conventional type, e.g. a tube, bag (such as a bag typically used for blood or blood products, e.g. plasma, or for infusion feeds, e.g. of nutrients), chamber, pouch or other structure, e.g. of polymer film, which can contain the irrigant fluid.
The reservoir may be made of a film, sheet or membrane, often with a (generally uniform) thickness similar to that of films or sheets used in conventional wound dressing backing layers, i.e. up to 100 micron, preferably up to 50 micron, more preferably up to 25 micron, and of 10 micron minimum thickness, and is often a resiliently flexible, e.g. elastomeric, and preferably soft, hollow body.

In all embodiments of the apparatus the type and material of the tubes throughout the apparatus of the invention for aspirating, irrigating and/or cleansing wounds and the fluid reservoir will be largely determined by their function.

To be suitable for use, in particular on chronic timescales, the material should be non-toxic and biocompatible, inert to any active components, as appropriate of the irrigant from the fluid reservoir and/or wound exudate in the apparatus flow path.

When in contact with irrigant fluid, it should not allow any significant amounts of extractables to diffuse freely out of it in use of the apparatus.

It should be sterilisable by ultraviolet, gamma or electron beam irradiation and/or with fluid antiseptics, such as solutions of chemicals, fluid- and microbe-impermeable once in use, and flexible.

Examples of suitable materials for the fluid reservoir include synthetic polymeric materials, such as polyolefins, such as polyethylene, e.g. high-density polyethylene and polypropylene.

Suitable materials for the present purpose also include copolymers thereof, for example with vinyl acetate and mixtures thereof. Suitable materials for the present purpose further include medical grade poly(vinyl chloride).

Notwithstanding such polymeric materials, the fluid reservoir will often have a stiff area to resist any substantial play between it and components that are not mutually integral, such as the fluid supply tube.
It may be stiffened, reinforced or otherwise strengthened, e.g. by a projecting boss.

The conduits through which respectively the irrigant and/or wound exudate passes to and from the wound dressing and

i) preferably have means for modular disconnection and withdrawal of the dressing,

ii) providing an immediate fluid-tight seal or closure over the ends of the conduits and the cooperating tubes in the rest of the apparatus of the invention so exposed,

to prevent continuing passage of irrigant and/or exudate and cleansed fluid, and cleansing fluid.

The outlet from the means for aspirate flow regulation and/or tubes may be collected and monitored and used to diagnose the status of the wound and/or its exudate.

Any waste reservoir may be of any conventional type, e.g. a tube, bag (such as a bag typically used as an ostomy bag), chamber, pouch or other structure, e.g. of polymer film, which can contain the irrigant fluid that has been bled off. In all embodiments of the apparatus, the type and material of the waste reservoir will be largely determined by its function.

To be suitable for use, the material need only be fluid-impermeable once in use, and flexible.

Examples of suitable materials for the fluid reservoir include synthetic polymeric materials, such as polyolefins, such as poly (vinylidene chloride).

Suitable materials for the present purpose also include polyethylene, e.g. high-density polyethylene, polypropylene, copolymers thereof, for example with vinyl acetate and mixtures thereof.

In a second aspect of the present invention there is provided a conformable wound dressing, characterised in that it comprises a backing layer with a wound-facing face which is capable of forming a relatively fluid-tight seal or closure over a wound and has
at least one inlet pipe for connection to a fluid supply tube, which passes through and/or under the wound-facing face, and
at least one outlet pipe for connection to a fluid offtake tube, which passes through and/or under the wound-facing face,
the point at which the or each inlet pipe and the or each outlet pipe passes through and/or under the wound-facing face forming a relatively fluid-tight seal or closure over the wound.
The dressing is advantageously provided for use in a bacteria-proof pouch.

Examples of suitable forms of such wound dressings are as described by way of example hereinbefore.

It is foreseen that the actives to be added to the wound bed maybe the nutrient medium, that human or mammalian cells e.g. keratinocytes, fibroblast or a mixture of these cells, or others for instance, have grown in (conditioned media). The cells will release beneficial actives to the media e.g. TGFβ that would benefit the wound bed and aid healing of the wound.

In some embodiments of the present invention the actual cells themselves with or without the cells growth media, maybe used as an active to the wound bed to aid healing. In particular embodiments of the present invention different types of cells maybe used as actives at different times of the healing process. For example, fibroblast type cells maybe used as an active to the wound bed to aid healing initially in order to help would remodelling and aid the wound to lay down structural fibres. Then keratinocytes or a larger proportion of keratinocytes than initially used before could be used as an active flowing along the wound bed to aid healing. Other cells could be used as well or combination thereof.

It is foreseen that the cells (keratinocytes or fibroblasts) can aid healing of the wound by giving beneficial healing components or by sticking to the wound bed and aiding healing directly.

When conditioned media is used, (the media that has had cells grown in it) different conditioned media from different cell source may be used and it is envisaged that having a particular order to which conditioned media to use may be important and aid healing. For example, conditioned media from fibroblast type cells or a mixture of cells comprising a high proportion of fibroblast cells may be used initially followed by a conditioned media from keratinocyte type cells or a mixture of cells comprising a higher proportion of keratinocyte than used before. It is foreseen that this will aid healing of the wound.

In some embodiments of the present invention there may be a wound contact layer. The wound contact layer may be made from any suitable material known in the art (e.g. gauze or foam) which will allow nutrients to reach the wound bed. Having a wound contact layer may prevent overgrowth of the granulation material.

In some embodiments of the present invention, a significant advantage, in particular in chronic wounds, is that in use granulation tissue is encouraged to grow onto and/or into the wound contact layer that lies between the wound film dressing and the wound bed.

The effect may be further enhanced by the circulation over the wound bed of irrigant from the fluid reservoir which contains nutrients for wound cells to aid proliferation, and other molecules that are beneficially involved in wound healing and/or that are favourable to the wound healing process.

A further particular advantage is that it is unnecessary to remove this granulation tissue in-growth on dressing change, as the wound contact layer may be left between the wound film dressing and the wound bed biodegrade. This minimises trauma and any need for debridement.

A particular advantage of this wound contact layer is its use with pressure sores: the device can be placed in the depths of the wound and the patient

can lie upon it without either affecting the utility of the device or further damaging the wound. This becomes critical if the patient cannot be moved from this posture for other medical reasons.

The wound contact layer is placed over substantially the expanse of the wound, and its size and configuration can be adjusted to fit the individual wound. It can be formed from a variety of apertured, semi-rigid materials.

By 'apertured' herein is meant materials that are porous, apertured, holed, open-mesh, slit, incised and/or cut.

The material must be sufficiently apertured to allow for invasion by all manner of cells involved in the process of tissue repair and wound healing, and/or for the inward growth of blood vessels, and sufficiently rigid to prevent overgrowth and collapse under suction.

Suitable biomaterials for a biodegradable wound contact layer include poly(hydroxy acids) and esters thereof, such as poly(glycolic acid), poly(L-lactic acid), poly(D-lactic acid) and esters thereof, and copolymers and blends of the aforementioned.

Suitable biomaterials also include poly(acid anhydrides), such as poly(terephthalic acid), poly(adipic acid) and copolymers and blends of the aforementioned.

Additionally, biologically sourced biodegradable polymeric materials may be used, such as substantially protein based polymers, for example collagens, fibronectins, or fibrins, either as whole molecules or those subjected to proteolytic or chemical treatments, in either degraded or native conformations, or modified protein based polymers produced by nucleic acids recombinant techniques, for example, collagens, fibronectins, or fibrins, or fragments thereof, produced through recombinant DNA techniques; or blends thereof.

Further acceptable wound contact layers will be combinations of protein based scaffolds and carbohydrate based polymers such as glycosoaminoglycans, chitosans, cellulose or alginate molecules.

Suitable materials also include human or animal derived tissues processed in means to make them acceptable in placement into the wound such as skin, alimentary tract or connective tissues.

The wound contact layer/material may be formed in a variety of apertured, semi-rigid forms.

These forms may be essentially two-dimensional, such as sheets, layers, films, flexible panels, meshes, nets, webs or lattices. They may be planed in the wound as dry, hydrated or gel based formulations.

One embodiment of apertured or holed scaffold comprises a section of honeycombed polymer sheet cut to the shape of the wound.

Where the wound contact layer is in an essentially two-dimensional apertured, semi-rigid form, such as a sheet, layer, film, flexible panel, mesh, net, web or lattice, it may be designed in a configuration that is able to conform well to the wound bed on insertion into the wound.

This conforming to shape is then a particular advantage in those embodiments where the wound dressing is used on deeper wounds, especially where a wound filler is used to urge the wound dressing towards the wound contact layer and wound bed, as described hereinafter in connection with the wound dressing.

By way of example, such a wound contact layer may be in the form of a deeply indented circular disc much like a multiple Maltese cross or a stylised rose. This form is able to conform well to the wound bed on insertion into the wound, especially a deeper wound, by the arms closing in and possibly overlapping.

The form of the wound contact layer may also be three-dimensional, such as sheets, layers, films, flexible panels, meshes, nets, webs and lattices, folded, creased, pleated, tucked, crinkled, crumpled, screwed up or twisted into a three-dimensional form./

Alternatively, these forms may be inherently three-dimensional, such as multilayers of films, flexible panels, meshes, nets, webs and lattices, or three-dimensional meshes, nets, webs and lattices, and favourably foams. They may be placed in the wound as dry, hydrated or gel based formulations.

Embodiments of the present invention may also include:

a suction head having a first face;

a second face opposite said first face, wherein said second face is comprised of a plurality of projections, said projections defining a plurality of channels for facilitating flow of fluids to an opening in said second face and through said first face, wherein said opening is adapted for connection to a suction tube; and

a surgical drape having an aperture coincident said opening, said surgical drape extending over a region, and overlapping beyond the perimeter of said first face, and wherein said surgical drape comprises a flexible adhesive coated film adhered to said region of said first face and a release-coated backing extending over said second face and adhered to the overlapping portion of said surgical drape.

For distributing fluid across a wound surface, the present invention may also include:

a suction head having a first face;

a second face opposite said first face;

a plurality of projections coincident from said second face, wherein said projections form a contact surface with the wound surface, and wherein a plurality of channels for facilitating flow of fluids are defined between said projections, said channels remaining out of contact with the wound surface; and

an aperture in fluid communication with said channels formed by said projections and formed through said first face and second face.

Embodiments of the present invention may also comprise:

a method of using a therapeutic apparatus for stimulating the healing of wounds in mammals comprising the steps of:

inserting a porous pad into or on said wound such that said porous pad is in contact with said wound, wherein said porous pad has at least a partial outer surface and an inner body, said outer surface being adapted for contact with surface of said wound with small first pores no larger than about 100 microns in diameter to enhance biocompatibility;

securing said porous paid within said wound with the dressing cover to maintain a negative pressure at the site of said wound;

generating a negative pressure at said wound through said porous pad; and

collecting fluids from said wound through said porous pad.

In a third aspect of the present invention there is provided a method of treating wounds to promote wound healing, using physiologically active components from cells or tissue in therapeutically active amounts to promote wound healing, using the apparatus for aspirating, irrigating and/or cleansing wounds of the present invention.

The present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic view of an apparatus for aspirating, irrigating and/or cleansing a wound according to the first aspect of the present invention that has

a single device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing,

in combination with

means for supply flow regulation, connected to a fluid supply tube, and

means for aspirate flow regulation, connected to a fluid offtake tube.

Figure 2 is a schematic view of another apparatus for aspirating, irrigating and/or cleansing a wound according to the first aspect of the present invention that has

a first device for moving fluid through the wound applied to the aspirate in the fluid offtake tube downstream of and away from the wound dressing, with means for aspirate flow regulation, connected to a fluid offtake tube; and

a second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing.

Figures 3 to 7 are cross-sectional views of conformable wound dressings, of the second aspect of the present invention for aspirating and/or irrigating wounds.

In these, Figures 3a to 6a are cross-sectional plan views of the wound dressings, and Figures 3b to 6b are cross-sectional side views of the wound dressings.

Figures 8 to 10 are various views of inlet and outlet manifold layouts for the wound dressings of the second aspect of the present invention for respectively delivering fluid to, and collecting fluid from, the wound.

Figures 11A to D are variants of a two-pump system with essentially identical, and identically numbered, components as in Figure 2, except that there is

a pump bypass loop,

a filter downstream of the aspirate collection vessel, and

a bleed regulator, such as a rotary valve, connected to the fluid offtake tube or to the wound space, for the regulation of the positive or negative pressure applied to the wound.

Figures 12A to C are variants of a two-pump system with essentially identical, and identically numbered, components as in Figures 11, except that they have various means for varying the regulation of the positive or negative pressure applied to the wound.

Figures 13 to 26 are cross-sectional views of conformable wound dressings, of the second aspect of the present invention for aspirating and/or irrigating wounds.

Figures 27A and B are variants of a two-pump system with essentially identical, and identically numbered, components as in Figures 11, except that they have alternative means for handling the aspirate flow to the aspirate collection vessel under negative or positive pressure to the wound in simultaneous aspiration and irrigation of the wound, including in Figure 27B a third device for moving fluid into a waste bag.

Figure 28 is a single-pump system essentially with the omission from the apparatus of Figures 11 of the second device for moving irrigant fluid into the wound dressings.

Figure 29 shows a schematic representation of a simultaneous irrigate/ aspirate (SIA) and sequential irrigate/aspirate (SEQ) flow system.

Figure 30 shows increased WST activity of fibroblasts and thus increased proliferation of cells in a SIA system with actives from cells being added.

Figure 31 shows a summary of WST activity of fibroblasts in SEQ systems for 24h with or with "cells as actives" component (n=3).

Referring to Figure 1, the apparatus (1) for aspirating, irrigating and/or cleansing wounds comprises
a conformable wound dressing (2), having
a backing layer (3) which is capable of forming a relatively fluid-tight seal or closure (4) over a wound (5) and
one inlet pipe (6) for connection to a fluid supply tube (7), which passes through the wound-facing face of the backing layer (5) at (8), and
one outlet pipe (9) for connection to a fluid offtake tube (10), which passes through the backing layer (3)/wound-facing face at (11),
the points (8), (11) at which the inlet pipe and the outlet pipe passes through and/or under the backing layer (3)/wound-facing face forming a relatively fluid-tight seal or closure over the wound;

the inlet pipe being connected via means for supply flow regulation, here a valve (14), by the fluid supply tube (7) to means for supplying physiologically active agents from cells or tissue to the wound, here a fluid reservoir (12A) and a container that contains a cell or tissue component (12B) connected to the supply tube (7), and

the outlet pipe (9) being connected via means for aspirate flow regulation, here a valve (16) and a fluid offtake tube (10) to waste, e.g. to a collection bag (not shown);

a device for moving fluid through the wound (5), here a diaphragm pump (18), e.g. preferably a small portable diaphragm pump, acting on the fluid offtake tube (10) to apply a low negative pressure on the wound; and

the valve (14) in the fluid supply tube (7), the valve (16) in the fluid aspiration tube (13), and the diaphragm pump (18), providing means for providing simultaneous aspiration and irrigation of the wound (5),

such that fluid may be supplied to fill the flowpath from the fluid reservoir via the container that contains the cell or tissue component, in turn connected to a supply tube,

fluid supply tube (via the means for supply flow regulation) and moved by the device through the flow path.

The operation of the apparatus is as described hereinbefore. In use, the inlet pipe, means for supply flow regulation, here valve (14), the fluid supply tube (7) and the container for cells or tissue (12B) contain physiologically active components from the cells or tissue in therapeutically active amounts to promote wound healing, and adds such materials into the flowpath.

The supply of such physiologically active materials is here effected to the wound via the fluid passing through the wound dressing from irrigant in the container that contains the cells or tissue.

Referring to Figure 2, the apparatus (21) is a variant two-pump system with essentially identical, and identically numbered, components as in Figure 1, except that

there is no means such as a valve for supply flow regulation in the fluid supply tube (7) from the means for supplying physiologically active agents from cells or tissue to the wound, here a fluid reservoir (12A) and a

container that contains a cell or tissue component (12B) connected to the supply tube (7), and
there is
a first device for moving fluid through the wound (5), here a diaphragm pump (18A), e.g. preferably a small portable diaphragm pump, acting on the fluid aspiration tube (13) downstream of and away from the wound dressing to apply a low negative pressure on the wound; with
means for aspirate flow regulation here a bleed valve (16) connected to the fluid aspiration tube (13) and a vacuum vessel (aspirant collection jar) (19); and
a second device for moving fluid through the wound (5), here a peristaltic pump (18B), e.g. preferably a small portable peristaltic pump, applied to the irrigant in the fluid supply tube (7) upstream of and towards the wound dressing,
the first device (18A) and second device (18B), and the valve (16) in the fluid aspiration tube (10), providing means for providing simultaneous (or sequential) aspiration and irrigation of the wound (5).

The operation of the apparatus is as described hereinbefore

Referring to Figures 3 to 6, each dressing (41) is in the form of a conformable body defined by a microbe-impermeable film backing layer (42) with a uniform thickness of 25 micron, with a wound-facing face (43) which is capable of forming a relatively fluid-tight seal or closure over a wound.

The backing layer (42) extends in use on a wound over the skin around the wound. On the proximal face of the backing layer (43) on the overlap (44), it bears an adhesive film (45), to attach it to the skin sufficiently to hold the wound dressing in place in a fluid-tight seal around the periphery of the wound-facing face (43) of the wound dressing.

There is one inlet pipe (46) for connection to a fluid supply tube (not shown), which passes through and/or under the wound-facing face (43), and one outlet pipe (47) for connection to a fluid offtake tube (not shown), which passes through and/or under the wound-facing face (43).

Referring to Figures 3a and 3b, one form of the dressing is provided with a wound filler (48) under a circular backing layer (42). This comprises a generally frustroconical, toroidal conformable hollow body, defined by a membrane (49) which is filled with a fluid, here air or nitrogen, that urges it to the wound shape. The filler (48) may be permanently attached to the backing layer with an adhesive film (not shown) or by heat-sealing.

The inlet pipe (46) and outlet pipe (47) are mounted centrally in the backing layer (42) above the central tunnel (50) of the toroidal hollow body (48) and each passes through the backing layer (42). In other embodiments the inlet (46) and outlet (47) pipes may pass under the backing layer (42).

Each extends in pipes (51) and (52) respectively through the tunnel (50) of the toroidal hollow body (48) and then radially in diametrically opposite directions under the body (48). This form of the dressing is a more suitable layout for deeper wounds.

Referring to Figures 4a and 4b, a more suitable form for shallower wounds is shown. This comprises a circular backing layer (42) and a circular upwardly dished first membrane (61) with apertures (62) that is permanently attached to the backing layer (42) by heat-sealing to form a circular pouch (63).

The pouch (63) communicates with the inlet pipe (46) through a hole (64), and thus effectively forms an inlet pipe manifold that delivers the aspirating fluid directly to the wound when the dressing is in use.

An annular second membrane (65) with openings (66) is permanently attached to the backing layer (42) by heat-sealing to form an annular chamber (67) with the layer (42).

The chamber (67) communicates with the outlet pipe (47) through an orifice (68), and thus effectively forms an outlet pipe manifold that collects the fluid directly from the wound when the dressing is in use.

Referring to Figures 5a and 5b, a variant of the dressing of Figures 4a and 4b that is a more suitable form for deeper wounds is shown. This

comprises a circular backing layer (42) and a filler (69), in the form of an inverted frustroconical, solid integer, here a resilient elastomeric foam, formed of a thermoplastic, or preferably a cross-linked plastics foam. It may be permanently attached to the backing layer (42), with an adhesive film (not shown) or by heat-sealing.

A circular upwardly dished sheet (70) lies under and conforms to, but is a separate structure, permanently unattached to, the backing layer (42) and the solid integer (69). A circular upwardly dished first membrane (71) with apertures (72) is permanently attached to the sheet (70) by heat-sealing to form a circular pouch (73) with the sheet (70). The pouch (73) communicates with the inlet pipe (46) through a hole (74), and thus effectively forms an inlet pipe manifold that delivers the aspirating fluid directly to the wound when the dressing is in use.

An annular second membrane (75) with openings (76) is permanently attached to the sheet (70) by heat-sealing to form an annular chamber (77) with the sheet (70). The chamber (77) communicates with the outlet pipe (47) through an orifice (78), and thus effectively forms an outlet pipe manifold that collects the fluid directly from the wound when the dressing is in use.

Alternatively, where appropriate the dressing may be provided in a form in which the circular upwardly dished sheet (70) functions as the backing layer and the solid filler (69) sits on the sheet (70) as the backing layer, rather than under it. The filler (69) is held in place with an adhesive film or tape, instead of the backing layer (42).

Referring to Figures 6a and 6b, a dressing that is a more suitable form for deeper wounds is shown. This comprises a circular backing layer (42) and a filler (79), in the form of an inverted generally hemispherical integer, permanently attached to the backing layer with an adhesive film (not shown) or by heat-sealing. Here it is a resilient elastomeric foam or a hollow body filled with a fluid, here a gel that urges it to the wound shape. The inlet pipe (46) and outlet pipe (47) are mounted peripherally in the backing layer (42).

A circular upwardly dished sheet (80) lies under and conforms to, but is a separate structure, permanently unattached to, the backing layer (42) and the filler (79).

A circular upwardly dished bilaminate membrane (81) has a closed channel (82) between its laminar components, with perforations (83) along its length on the outer surface (84) of the dish formed by the membrane (81) and an opening (85) at the outer end of its spiral helix, through which the channel (82) communicates with the inlet pipe (46), and thus effectively forms an inlet pipe manifold that delivers the aspirating fluid directly to the wound when the dressing is in use.

The membrane (81) also has apertures (86) between and along the length of the turns of the channel (82). The inner surface (87) of the dish formed by the membrane (81) is permanently attached at its innermost points (88) with an adhesive film (not shown) or by heat-sealing to the sheet (80). This defines a mating closed spirohelical conduit (89). At the outermost end of its spiral helix, the conduit (89) communicates through an opening (90) with the outlet pipe (47) and is thus effectively an outlet manifold to collect the fluid directly from the wound via the apertures (86).

Referring to Figures 7a and 7b, one form of the dressing is provided with a circular backing layer (42). A first (larger) inverted hemispherical membrane (92) is permanently attached centrally to the layer (42) by heat-sealing to form a hemispherical chamber (94) with the layer (42). A second (smaller) concentric hemispherical membrane (93) within the first is permanently attached to the layer (42) by heat-sealing to form a hemispherical pouch (95).

The pouch (95) communicates with the inlet pipe (46) and is thus effectively an inlet manifold, from which pipes (97) radiate hemispherically and run to the wound bed to end in apertures (98). The pipes (97) deliver the aspirating fluid directly to the wound bed via the apertures (98).

The chamber (94) communicates with the outlet pipe (47) and is thus effectively an outlet manifold from which tubules (99) radiate

hemispherically and run to the wound bed to end in openings (100). The tubules (99) collect the fluid directly from the wound via the openings (100).

Referring to Figures 8a to 8d, one form of the dressing is provided with a square backing layer (42) and
first tube (101) extending from the inlet pipe (46), and
second tube (102) extending from the outlet pipe (47)
at the points at which they pass through the backing layer, to run over the wound bed.

These pipes (101), (102) have a blind bore with orifices (103), (104) along the pipes (101), (102). These pipes (101), (102) respectively form an inlet pipe or outlet pipe manifold that delivers the aspirating fluid directly to the wound bed or collects the fluid directly from the wound respectively via the orifices.

In Figures 8a and 8d, one layout of each of the pipes (101), (102) as inlet pipe and outlet pipe manifolds is a spiral.

In Figure 8b, the layout is a variant of that of Figures 8a and 8b, with the layout of the inlet manifold (101) being a full or partial torus, and the outlet manifold (102) being a radial pipe.

Referring to Figure 8c, there is shown another suitable layout in which the inlet manifold (101) and the outlet manifold (102) run alongside each other over the wound bed in a boustrophedic pattern, i.e. in the manner of ploughed furrows.

Referring to Figures 9a to 9d, there are shown other suitable layouts for deeper wounds, which are the same as shown in Figures 8a to 8d. The square backing layer (42) however has a wound filler (110) under, and may be permanently attached to, the backing layer (42), with an adhesive film (not shown) or by heat-sealing.

The filler (110) is an inverted hemispherical solid integer, here a resilient elastomeric foam, formed of a thermoplastic, preferably a cross-linked plastics foam.

Under the latter is a circular upwardly dished sheet (111) which conforms to, but is a separate structure, permanently unattached to, the solid filler (110). Through the sheet (111) pass the inlet pipe (46) and the outlet pipe (47), to run over the wound bed. These pipes (101), (102) again have a blind bore with orifices (103), (104) along the pipes (101), (102).

Alternatively (as in Figures 5a and 5b), where appropriate the dressing may be provided in a form in which the circular upwardly dished sheet (111) functions as the backing layer and the solid filler (110) sits on the sheet (42) as the backing layer, rather than under it. The filler (110) is held in place with an adhesive film or tape, instead of the backing layer (42).

In Figures 10a to 10c, inlet and outlet manifolds for the wound dressings for respectively delivering fluid to, and collecting fluid from, the wound, are formed by slots in and apertures through layers permanently attached to each other in a stack.

Thus, in Figure 10a there is shown an exploded isometric view of an inlet manifold and outlet manifold stack (120) of five square coterminous thermoplastic polymer layers, being first to fifth layers (121) to (125), each attached with an adhesive film (not shown) or by heat-sealing to the adjacent layer in the stack (120).

The topmost (first) layer (121) (which is the most distal in the dressing in use) is a blank square capping layer.

The next (second) layer (122), shown in Figure 10b out of the manifold stack (120), is a square layer, with an inlet manifold slot (126) through it. The slot (126) runs to one edge (127) of the layer (122) for connection to a mating end of a fluid inlet tube ((not shown), and spreads into four adjacent branches (128) in a parallel array with spaces therebetween.

The next (third) layer (123) is another square layer, with inlet manifold apertures (129) through the layer (123) in an array such that the apertures (129) are in register with the inlet manifold slot (126) through the second layer (122) (shown in Figure 10b).

The next (fourth) layer (124), shown in Figure 10c out of the manifold stack (120), is another square layer, with inlet manifold apertures (130) through the layer (124) in an array such that the apertures (130) are in register with the apertures (129) through the third layer (123).

It also has an outlet manifold slot (131) through it. The slot (131) runs to one edge (132) of the layer (124) on the opposite side of the manifold stack (120) from the edge (127) of the layer (122), for connection to a mating end of a fluid outlet tube (not shown).

It spreads into three adjacent branches (133) in a parallel array in the spaces between the apertures (130) in the layer (124) and in register with the spaces between the apertures (129) in the layer (122).

The final (fifth) layer (125) is another square layer, with inlet manifold apertures (134) through the layer (125) in an array such that the apertures (134) are in register with the inlet manifold apertures (130) through the fourth layer (124) (in turn in register with the apertures (129) through the third layer (123). It also has outlet manifold apertures (135) in the layer (125) in an array such that the apertures (135) are in register with the outlet manifold slot (131) in the fourth layer (124).

It will be seen that, when the layers (121) to (125) are attached together to form the stack (120), the topmost (first) layer (121), the inlet manifold slot (126) through the second layer (122), and the third layer (123) cooperate to form an inlet manifold in the second layer (122), which is in use is connected to a mating end of a fluid inlet tube (not shown).
The inlet manifold slot (126) through the second layer (122), and the inlet manifold apertures (129), (130) and (134) through the layers (123), (124) and (125), are all mutually in register.

They thus cooperate to form inlet manifold conduits through the third to fifth layers (123), (124) and (125) between the inlet manifold in the second layer (122) and the proximal face (136) of the stack (120).

The third layer (121), the outlet manifold slot (131) through the fourth layer (124), and the fifth layer (125) cooperate to form an outlet manifold in the fourth layer (124), which is in use is connected to a mating end of a fluid outlet tube (not shown).

The outlet manifold slot (131) through the fourth layer (124), and the outlet manifold apertures (135) through the fifth layer (125), being mutually in register, cooperate to form outlet manifold conduits though the fifth layer (125) between the outlet manifold in the fourth layer (124) and the proximal face (136) of the stack (120).

Referring to Figure 11A, the apparatus (21) is a variant two-pump system with essentially identical, and identically numbered, components as in Figure 2.

Thus, there is
a means for supply flow regulation, here a valve (14) in the fluid supply tube (7) from the fluid reservoir (12B), and
a first device for moving fluid through the wound (5), here a fixed-speed diaphragm pump (18A), e.g. preferably a small portable diaphragm pump, acting not on the fluid aspiration tube (13), but on an air aspiration tube (113) downstream of and away from an aspirate collection vessel (19) to apply a low negative pressure on the wound through the aspirate collection vessel (19); with
a second device for moving fluid through the wound (5), here a fixed-speed peristaltic pump (18B), e.g. preferably a small portable peristaltic pump, applied to the irrigant in the fluid supply tube (7) upstream of and towards the wound dressing,
the first device (18A) and second device (18B), and the valve (14) in the fluid supply tube (7), providing means for providing simultaneous aspiration and irrigation of the wound (5),
such that fluid may be supplied to fill the flowpath from the fluid reservoir via the fluid supply tube (via the means for supply flow regulation) and moved by the devices through the flow path.

There is no means for aspirate flow regulation, e.g. a valve, connected to the fluid offtake tube (10).

Since first device (18A) and second device (18B) are fixed-speed, the valve (14) in the fluid supply tube (7) provides the sole means for varying the irrigant flow rate and the low negative pressure on the wound.

The following extra features are present:

The second device, the fixed-speed peristaltic pump (18B), is provided with means for avoiding over-pressure, in the form of a bypass loop with a non-return valve (115).

The loop runs from the fluid supply tube (7) downstream of the pump (18B) to a point in the fluid supply tube (7) upstream of the pump (18B).

A pressure monitor (116) connected to the fluid offtake tube (10) has a feedback connection to a bleed regulator, here a motorised rotary valve (117) on a bleed tube (118) running to and centrally penetrating the top of the aspirate collection vessel (19). This provides means for holding the low negative pressure on the wound at a steady level.

A filter (119) downstream of the aspirate collection vessel (19) prevents passage of gas- (often air-) borne particulates, including liquids and micro-organisms, from the irrigant and/or exudate that passes into the aspirate collection vessel (19) into the first device (18A), whilst allowing the carrier gas to pass through the air aspiration tube (13) downstream of it to the first device (18A). The operation of the apparatus is as described hereinbefore. Referring to Figure 11B, this shows an alternative layout of the essentially identical, and identically numbered, components in Figure 11A downstream of point A in Figure 11A.

The bleed tube (118) runs to the air aspiration tube (113) downstream of the filter (119), rather than into the aspirate collection vessel (19). This provides means for holding the low negative pressure on the wound at a steady level. The operation of the apparatus is as described hereinbefore.

Referring to Figure 11C, this shows an alternative layout of the essentially identical, and identically numbered, components in Figure 11A upstream of point B in Figure 11A. The second device (18B) is a variable-speed pump,

and the valve (14) in the fluid supply tube (7) is omitted. The second device (18B) is the sole means for varying the irrigant flow rate. The operation of the apparatus is as described hereinbefore.

Referring to Figure 11D, this shows an alternative layout of the essentially identical, and identically numbered, components in Figure 11A downstream of point B in Figure 11A. The pressure monitor (116) is connected to a monitor offtake tube (120) and has a feedback connection to the bleed regulator, motorised rotary valve (117) on a bleed tube (118) running to the monitor offtake tube (120). This provides means for holding the low negative pressure on the wound at a steady level. The operation of the apparatus is as described hereinbefore.

Referring to Figure 12A, this shows another alternative layout of the essentially identical, and identically numbered, components in Figure 11A downstream of point B in Figure 11A.

The pressure monitor (116) is connected to a monitor offtake tube (120). It has a feedback connection to a means for aspirate flow regulation, here a motorised valve (16).

The valve (16) is in the fluid offtake tube (10) upstream of the aspirate collection vessel (19), and provides means for aspirate flow regulation and for holding the low negative pressure on the wound at a steady level. The operation of the apparatus is as described hereinbefore.

Referring to Figure 12B, this shows another alternative layout of the essentially identical, and identically numbered, components in Figure 12A downstream of point B in Figure 11A.

The pressure monitor (116) is connected to a monitor offtake tube (120) and has a feedback connection to a means for aspirate flow regulation, here a motorised valve (16) in the air aspiration tube (113) downstream of the filter (119).

This provides means for aspirate flow regulation and for holding the low negative pressure on the wound at a steady level. The operation of the apparatus is as described hereinbefore.

Referring to Figure 12C, this shows another alternative layout of the essentially identical, and identically numbered, components in Figure 12A downstream of point B in Figure 11A.

The pressure monitor (116) is connected to a monitor offtake tube (120) and has a feedback connection to a variable-speed first device (18A), here a variable-speed pump, downstream of the filter (119), and the valve (16) in the fluid offtake tube (10) is omitted. This provides means for aspirate flow regulation and for holding the low negative pressure on the wound at a steady level.

The operation of the apparatus is as described hereinbefore.

Referring to Figures 13 to 15, these forms of the dressing are provided with a wound filler (348) under a circular backing layer (342). This comprises respectively a generally downwardly domed or toroidal, or oblately spheroidal conformable hollow body, defined by a membrane (349) which is filled with a fluid, here air or nitrogen, that urges it to the wound shape.

The filler (348) is permanently attached to the backing layer via a boss (351), which is e.g. heat-sealed to the backing layer (342).
An inflation inlet pipe (350), inlet pipe (346) and outlet pipe (347) are mounted centrally in the boss (351) in the backing layer (342) above the hollow body (348). The inflation inlet pipe (350) communicates with the interior of the hollow body (348), to permit inflation of the body (348). The inlet pipe (346) extends in a pipe (352) effectively through the hollow body (348). The outlet pipe (347) extends radially immediately under the backing layer (342).

In Figure 13, the pipe (352) communicates with an inlet manifold (353), formed by a membrane (361) with apertures (362) that is permanently attached to the filler (348) by heat-sealing.

It is filled with foam (363) formed of a suitable material, e.g. a resilient thermoplastic. Preferred materials include reticulated filtration polyurethane foams with small apertures or pores.

In Figure 14, the outlet pipe (347) communicates with a layer of foam (364) formed of a suitable material, e.g. a resilient thermoplastic. Again, preferred materials include reticulated filtration polyurethane foams with small apertures or pores.

In all of Figures 13, 14 and 15, in use, the pipe (346) ends in one or more openings that deliver the irrigant fluid directly from the wound bed over an extended area. Similarly, the outlet pipe (347) effectively collects the fluid radially from the wound periphery when the dressing is in use.

Referring to Figure 16, the dressing is also provided with a wound filler (348) under a circular backing layer (342). This also comprises a generally toroidal conformable hollow body, defined by a membrane (349) which is filled with a fluid, here air or nitrogen, that urges it to the wound shape. The filler (348) may be permanently attached to the backing layer (342) via a first boss (351) and a layer of foam (364) formed of a suitable material, e.g. a resilient thermoplastic. Again, preferred materials include reticulated filtration polyurethane foams with small apertures or pores.

The first boss (351) and foam layer (364) are respectively heat-sealed to the backing layer (342) and the boss (351). An inflation inlet pipe (350), inlet pipe (346) and outlet pipe (347) are mounted centrally in the first boss (351) in the backing layer (342) above the toroidal hollow body (348). The inflation inlet pipe (350), inlet pipe (346) and outlet pipe (347) respectively each extend in a pipe (353), (354) and (355) through a central tunnel (356) in the hollow body (348) to a second boss (357) attached to the toroidal hollow body (348).

The pipe (353) communicates with the interior of the hollow body (348), to permit inflation of the body (348). The pipe (354) extends radially through the second boss (357) to communicate with an inlet manifold (352), formed by a membrane (361).

This is permanently attached to the filler (348) by heat-sealing in the form of a reticulated honeycomb with openings (362) that deliver the irrigant fluid directly to the wound bed over an extended area.

The pipe (355) collects the fluid flowing radially from the wound centre when the dressing is in use.

This form of the dressing is a more suitable layout for deeper wounds.

In Figure 17, the dressing is similar to that of Figure 16, except that the toroidal conformable hollow body, defined by a membrane (349), is filled with a fluid, here a solid particulate, such as plastics crumbs or beads, rather than a gas, such as air or an inert gas, such as nitrogen or argon. The inflation inlet pipe (350) and pipe (353) are therefore omitted from the central tunnel (356).

Examples of contents for the body (348) also include gels, such as silicone gels or preferably cellulosic gels, for example hydrophilic cross-linked cellulosic gels, such as Intrasite ™ cross-linked materials. Examples also include aerosol foams, and set aerosol foams, e.g. CaviCare™ foam.

Referring to Figures 18 and 19, another form for deeper wounds is shown. This comprises a circular backing layer (342) and a lobed chamber (363) in the form of a deeply indented disc much like a multiple Maltese cross or a stylised rose.

This is defined by an upper impervious membrane (361) and a lower porous film (362) with apertures (364) that deliver the irrigant fluid directly from the wound bed over an extended area. A number of configurations of the chamber (363) are shown, all of which are able to conform well to the wound bed by the arms closing in and possibly overlapping in insertion into the wound.

In a particular design of the chamber (363), shown lowermost, on of the arms extended and provided with an inlet port at the end of the extended arm. This provides the opportunity for coupling and decoupling the irrigant supply remote from the dressing and the wound in use.

An inlet pipe (346) and outlet pipe (347) are mounted centrally in a boss (351) in the backing layer (342) above the chamber (363). The inlet pipe (346) is permanently attached to, and communicate with the interior of, the chamber (363), which thus effectively forms an inlet manifold. The space above the chamber (363) is filled with a loose gauze packing (364). .

In Figure 18, the outlet pipe (347) collects the fluid from the interior of the dressing from just under the wound-facing face (343) of the backing layer (342).

A variant of the dressing of Figure 18 is shown in Figure 19. The outlet pipe (347) is mounted to open at the lowest point of the space above the chamber (363) into a piece of foam (374).

In Figure 20, the dressing is similar to that of Figure 13, except that the inlet pipe (352) communicates with an inlet manifold (353), formed by a membrane (361) with apertures (362), over the upper surface of the generally downwardly domed wound hollow filler (348), rather than through it.

In Figure 22, the dressing is similar to that of Figure 14, with the addition of an inlet manifold (353), formed by a membrane (361) with apertures (362), over the lower surface of the generally downwardly domed annular wound hollow filler.

In Figure 21, the generally downwardly domed annular wound hollow filler is omitted.

Referring to Figure 23, another form for deeper wounds is shown. An inlet pipe (346) and outlet pipe (347) are mounted centrally in a boss (351) in the backing layer (342) above a sealed-off foam filler (348).

The inlet pipe (346) is permanently attached to and passes through the filler (348) to the wound bed. The outlet pipe (347) is attached to and communicates with the interior of, a chamber (363) defined by a porous foam attached to the upper periphery of the filler (348). The chamber (363) thus effectively forms an outlet manifold.

In Figure 24, the foam filler (348) is only partially sealed-off.
The inlet pipe (346) is permanently attached to and passes through the filler (348) to the wound bed. The outlet pipe (347) is attached to and communicates with the interior of the foam of the filler (348).

Fluid passes into an annular gap (349) near the upper periphery of the filler (348) into the foam, which thus effectively forms an outlet manifold.

Figures 25 and 26 show dressings in which the inlet pipe (346) and outlet pipe (347) pass through the backing layer (342).

In Figure 25, they communicates with the interior of a porous bag filler (348) defined by a porous film (369) and filled with elastically resilient plastics bead or crumb.

In Figure 26, they communicate with the wound space just below a foam filler (348). The foam (348) maybe CaviCare ™ foam, injected and formed in situ around the pipes (346) and (347).
Referring to Figure 27A, this shows another alternative layout of the essentially identical, and identically numbered, components in Figure 12C downstream of point B in Figure 12A, and alternative means for handling the aspirate flow to the aspirate collection vessel under negative or positive pressure to the wound.

The pressure monitor (116) is connected to a monitor offtake tube (120) and has a feedback connection to a variable-speed first device (18A), here a variable-speed pump, upstream of the aspirate collection vessel (19), and the filter (119) and the air aspiration tube (113) are omitted. This provides means for aspirate flow regulation and for holding the low negative pressure on the wound at a steady level.

The operation of the apparatus is as described hereinbefore.

Referring to Figure 27B, this shows another alternative layout of the essentially identical, and identically numbered, components in Figure 12C downstream of point A in Figure 11A, and alternative means for handling

the aspirate flow to the aspirate collection vessel under negative or positive pressure to the wound.

The pressure monitor (116) is omitted, as is the feedback connection to a variable-speed first device (18A), here a variable-speed pump, downstream of the aspirate collection vessel (12A) and the filter (119).

A third device (18C), here a fixed-speed pump, provides means for moving fluid from the aspirate collection vessel (19) into a waste bag (12C).

The operation of the apparatus is as described hereinbefore.

Referring to Figure 28, this shows an alternative layout of the essentially identical, and identically numbered, components in Figure 11A upstream of point A in Figure 11A.

It is a single-pump system essentially with the omission from the apparatus of Figure 11A of the second device for moving irrigant fluid into the wound dressing.

The operation of the apparatus is as described hereinbefore.

Example 1

Using simultaneous irrigate/aspirate (SIA) and sequential irrigate/aspirate (SEQ), the effect of cells as a source of 'actives' on fibroblast proliferation was determined.

Method

Cells

Human dermal fibroblasts (HS8/BS04) grown at 37°C/5% CO_2, in T175 flasks containing 35 ml DMEM/10% FCS media were washed in PBS and lifted using 1 x trypsin/EDTA (37°C for 5 min). Trypsin inhibition was achieved by adding 10 ml DMEM/10% FCS media and the cells pelleted by centrifugation (Hereus Megafuge 1.0R; 1000 rpm for 5 min). The media was discarded and cells re-suspended in 10 ml DMEM/10% FCS. Cells

were counted using haemocytometer (SOP/CB/007) and diluted in DMEM/10% FCS to obtain 100,000 cells per ml.

Cells (100 µl of diluted stock) were transferred to 13mm Thermanox tissue culture coated cover slips (Fisher, cat. no. 174950, lot no. 591430) in a 24 well plate and incubated at 37°C in 5% CO_2 to allow for cell adherence. After 1 h, 1 ml DMEM/10% FCS media was added per well and the cells incubated for approximately 5 hours in the above conditions. Cells were serum starved overnight by removing the DMEM/10% FCS and washing the coverslips with 2 x 1 ml PBS prior to the addition of 1 ml DMEM/0% FCS.

Following overnight incubation, cells were assessed visually for cell adherence under the microscope and those with good adherence were inserted into cover slip holders for assembly in the Minucell chamber.

Media

Cells were grown in DMEM media (Sigma, cat. no. D6429) supplemented with 5 % foetal calf serum; l-glutamine, non-essential amino acids and penicillin/streptomycin. Media used in the experimental systems was buffered with 1 % (v/v) Buffer-All media (Sigma, cat. no. B8405, lot. no. 51k2311) to ensure stable pH of the media.

Minucell Flow systems

Media (50 ml) was transferred to each bottle prior to the autoclaved systems being assembled. The Minucell chambers were filled with 4 ml media prior to coverslips being inserted. The systems were set-up as shown in figure 29, set to run at 0.2 ml/min; hot plates, set to 45°C; Discofix 3-way valves; vacuum pump, (Ilmvac VCZ 310), set to 950mbar).

SEQ systems

Media was pumped through the systems at 0.2ml/min continuously when the chambers were full. The Minucell chambers were emptied by disconnecting the tubing from the pump and switching the 3-way valve to allow air through an attached 0.22 µm filter. When fully emptied, the 3-way valve was switched to close the system between the valve and the pump and so allowing the formation of a vacuum in the system. Elevation of the

3-way valve ensured media did not pass through the 0.22 μm filter by gravity flow. After 1 h, the 3-way valve was switched back to the starting position to allow the Minucell chamber to fill and the tube reconnected to the pump. The SEQ systems were treated as per table 1.

Table 1. Fill/empty regime for SEQ systems.

Time (h)	0	1	2	3	4	5	6	7	8	20	21	22	23	24
Empty/fill	F	E	F	E	F	E	F	E	F	E	F	E	W	A

F = full chamber/flowing; E = empty chamber/under vacuum; W = remove coverslips for WST assay; A = read WST assay result.

SIA systems

Continuous irrigate aspirate systems were run for 24 h with media irrigating the cells and being aspirated under vacuum set to 950mbar. The atmospheric pressure varied daily, up to a maximum value of 1048 mbar, therefore the difference in pressure between the systems and the atmosphere was always under 10 %.

Cells as actives component

The 'cells as actives' component of the flow cell system was provided by Dermagraft (a fibroblast seeded Vicryl mesh). Dermagraft stored at -70°C was defrosted by placing in a 37°C water-bath for 1 min and washed x3 with 50ml 0.9% v/v NaCl. The Dermagraft was cut into 24 x 1.1cm^2 squares using a sterile clicker-press and placed into DMEM/5% FCS. For the flow-cell experiments, a number of Dermagraft squares were placed in Media 1 bottle (figure 1) immediately prior to the start of the experiment. The presence of live cells in the Dermagraft squares was determined by WST assay when the experiment was terminated.

WST Assay

A WST assay to measure cell mitochondrial activity was performed on the coverslips. WST reagent (Roche, cat. no. 1 644 807, lot no. 11264000) was diluted to 10% v/v in DMEM/10% FCS. The coverslips (n=6) were removed from each Minucell chamber and washed in 1 ml PBS. PBS was removed and 200 μl WST/DMEM media added. The coverslips were then

incubated at 37°C for 45 min before transferring 150 µl to a 96 well plate. The absorbance at 450 nm with reference at 655 nm was determined using Ascent Multiskan Microtitre plate reader.

Results and discussion

The mitochondrial activity of cells grown in SIA and SEQ systems, with or without 'cells as actives' component was determined using the WST assay. The optimal number of Dermagraft squares required was first assessed in a SIA flow cell system. Addition of Dermagraft squares to the media had a beneficial effect, increasing the proliferation rate of seeded fibroblasts (figure 30). There was a slight benefit to increasing the number of Dermagraft squares from 3 to 6, although increasing the amount of Dermagraft to 11 squares did not further increase the rate of proliferation. Therefore, for the flow cell experiments, 6 Dermagraft squares were placed in the relevant media bottles. The experiments to show the optimal number of Dermagraft squares also showed that the addition of cells as a source of actives, to the SIA systems, resulted in an increased rate of proliferation (Fig. 30).

Conclusions

Treatment of fibroblasts by the addition of 'cells acting as a source of actives' to the media, increased the rate of proliferation in SIA and the SEQ systems after 24 hours (Fig. 30 & 31).

This beneficial effect was observed in both SAI and the SEQ flow systems.

Claims

1. An apparatus for aspirating, irrigating and/or cleansing wounds, comprising:

a) a fluid flow path comprising a wound dressing having a backing layer and at least one inlet pipe for connection to a fluid supply tube, which passes through and/or under the backing layer and at least one outlet pipe for connection to a fluid offtake tube, which passes through and/or under the backing layer;

b) at least one device for moving fluid through the wound dressing and characterised in that it comprises;

c) means for supplying physiologically active agents from cells, or tissue to the wound, connected to a fluid supply tube;

d) means for providing sequential or simultaneous aspiration and irrigation of the wounds, such that the fluid containing such physiologically active agents from the cells or tissue maybe supplied to fill the flow path via the fluid supply tube from the means for supplying physiologically active agents from cells or tissue to the wound.

2. An apparatus as claimed in claim 1 in which the backing layer is capable of forming a relatively fluid tight seal or closure over a wound.

3. An apparatus as claimed in either one of claims 1 or 2 in which the point at which the/or each inlet pipe and the/or each outlet pipe passes through and/or under the backing layer is capable of forming a relatively fluid-tight seal or closure over the wound.

4. An apparatus as claimed in any one of claims 1, 2 or 3 in which the wound dressing is a conformable wound dressing.

5. An apparatus as claimed in any preceding claim in which the means for supplying physiologically active agents to the wound comprises a fluid reservoir containing physiologically active components in therapeutically active amounts to promote wound healing.

6. An apparatus as claimed in any preceding claim in which the physiologically active agent derived from cells or tissues for supplying to the wound is the media that the cells or tissue were bathed or grown in (conditioned media).

7. An apparatus as claimed in any preceding claim in which the physiologically active agent for supplying to the wound also comprises cells.

8. An apparatus as claimed in claim 6 or 7 in which the cells comprise fibroblasts, keratinocytes or a mixture of fibroblasts and keratinocytes.

9. An apparatus as claimed in any one of the preceding claims in which the backing layer is semi permeable to allow a flow rate of gas through it.

10. An apparatus as claimed in any one of the preceding claims in which the apparatus comprises a wound contact layer.

11. An apparatus as claimed in claim 10 in which the wound contact layer is chosen from the group consisting of: gauze, foam, a porous means, a semi-permeable means or device, an elastic filler or material or an inflatable filler or device.

12. An apparatus as claimed in claim 1 or 6 in which the cells or tissue are mounted under the backing layer.

13. An apparatus as claimed in any one of the preceding claims in which the apparatus is portable.

14. An apparatus as claimed in either one of claims 1, 6 or 12 which the cells or tissue are bound on an insoluble substrate.

15. The apparatus of claim 1 wherein the device for moving fluid through the wound is a diaphragm pump or a peristaltic pump.

16. The apparatus of claim 1 in which the flow rate is a varied flow rate, either randomly or regularly cyclical.

17. The apparatus of claim 16 wherein the regular or random cycles of flow rate have a frequency of up to 48 per 24 hours.

18. The apparatus of claim 16 or 17 wherein the pulses of flow velocity have a frequency of from 1 to 60 per min.

19. The apparatus of claim 15 wherein the device for moving fluid across the wound imposes a flow which is a parallel flow, radial streaming, spiral streaming, helical streaming, spirohelical streaming or circular streaming.

20. An apparatus according to claim 1 in which the means for providing aspirating and irrigation of the wound comprises:

a) a first device for moving fluid through the wound applied to fluid downstream of and away from the wound dressing, and

b) a second device for moving fluid through the wound applied to the irrigant in the fluid supply tube upstream of and towards the wound dressing.

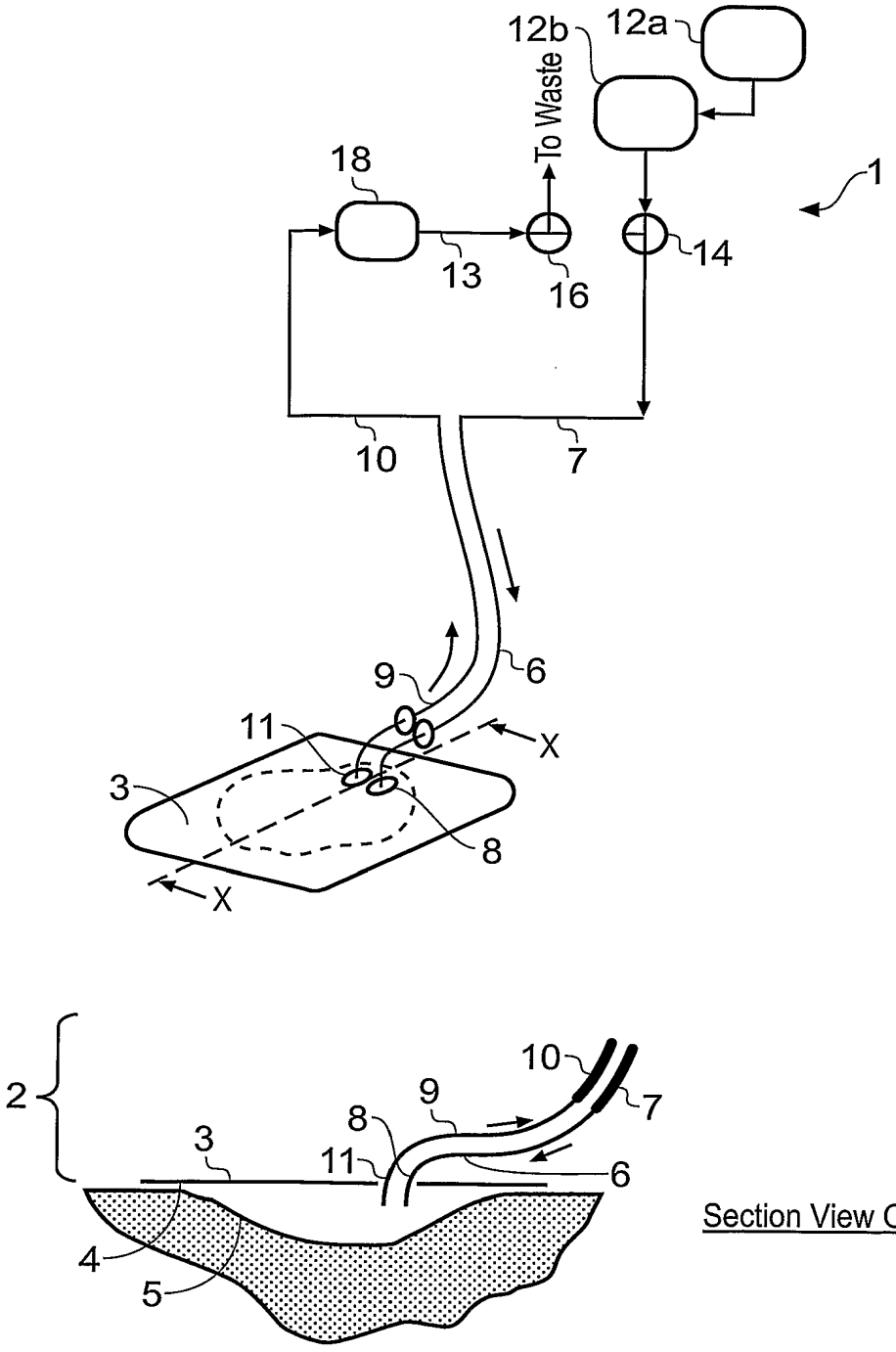
21. An apparatus according to claim 20 in which the first device and/or second device is a fixed throughput device and the means for providing aspiration and irrigation of the wound also comprise at least one of means for supply flow regulation, connected to a fluid supply tube, and means for aspirate flow regulation, connected to a fluid offtake tube.

22. An apparatus according to any preceding claim in which the aspirating means is also a vacuum means for creating a negative pressure on the area surrounding the wound.

23. An apparatus according to claim 22 in which the negative pressure is between about 1.01 and 100.3 kPa (0.01 and 0.99 atmospheres).

24. An apparatus to any preceding claim in which administers a reduced pressure treatment to the wound.

25. A method of treating wounds to promote wound healing using the apparatus according to claim 1.


12b
12a
To Waste
18
1
13
16
14
10
7
9
6
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Section View On X-X

Fig. 1

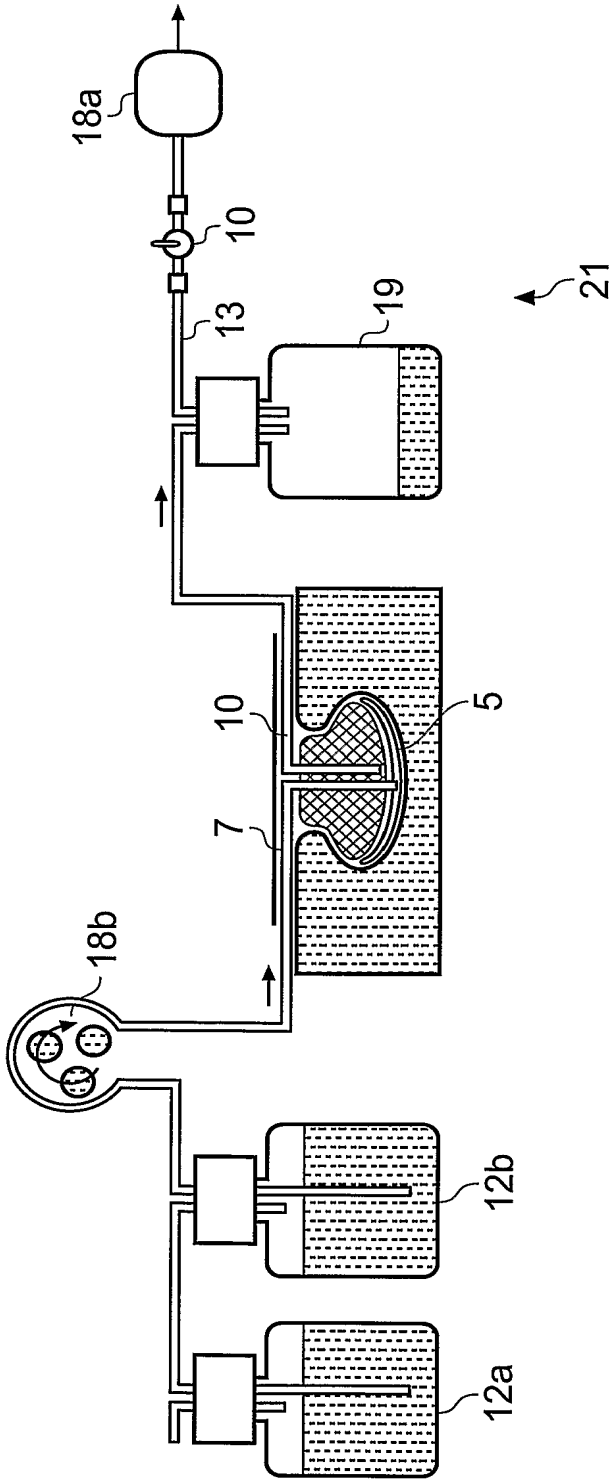


Fig. 2

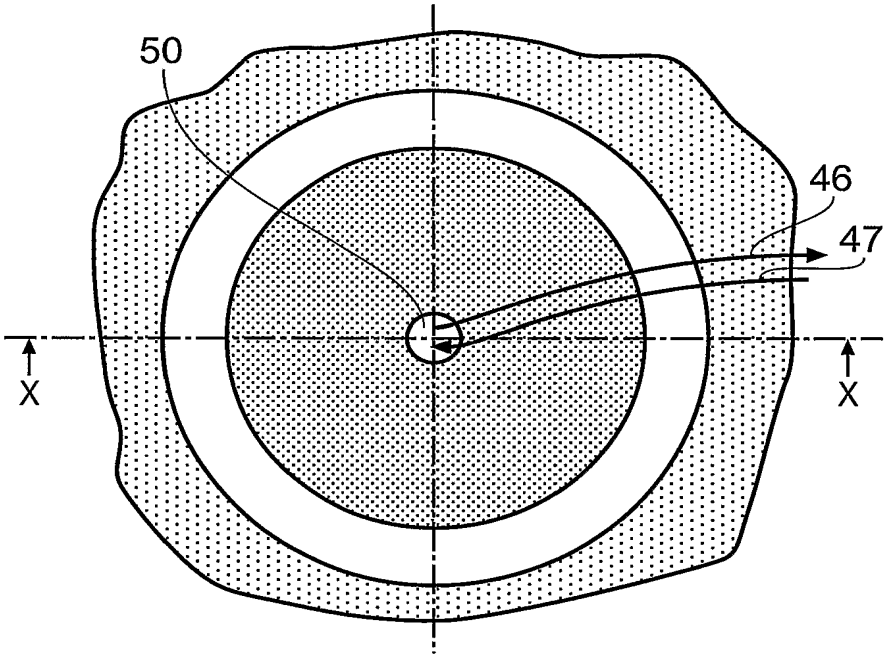
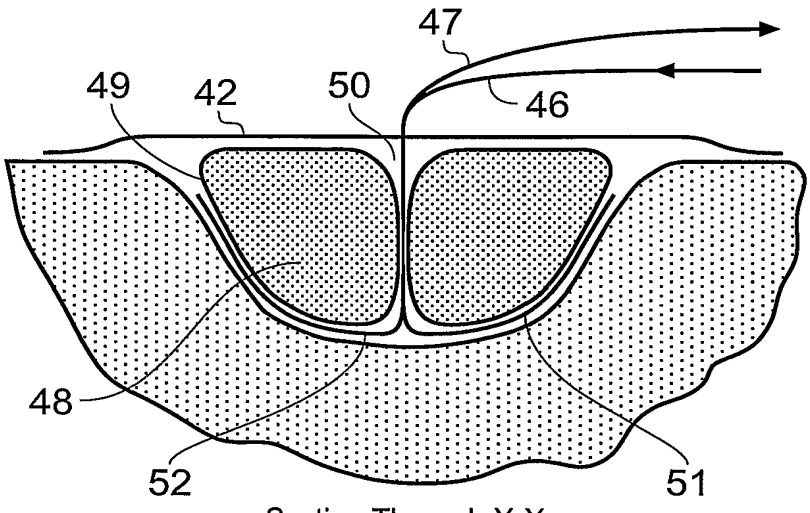
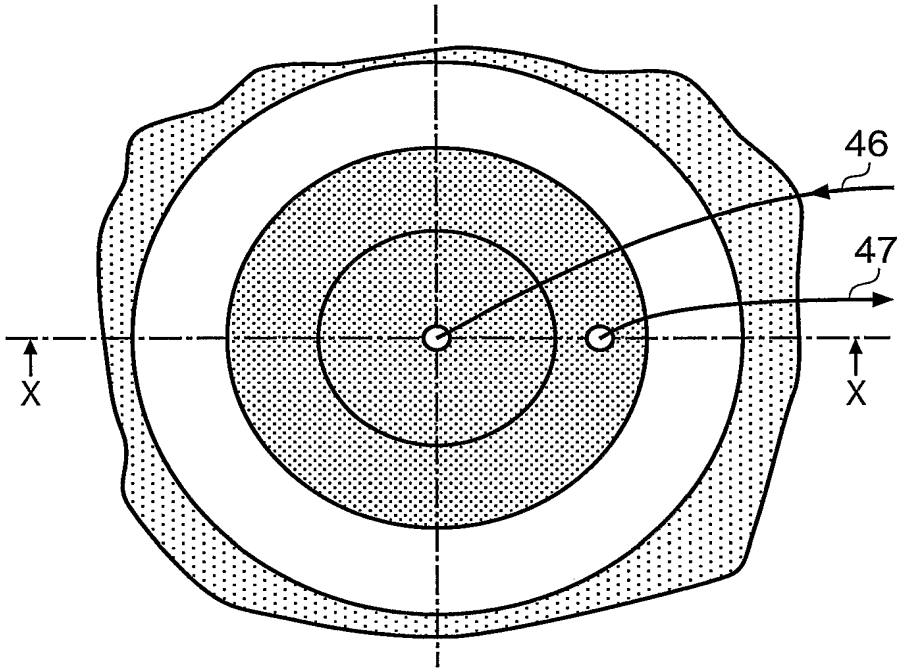


Fig. 3a



Section Through X-X

Fig. 3b


46
47
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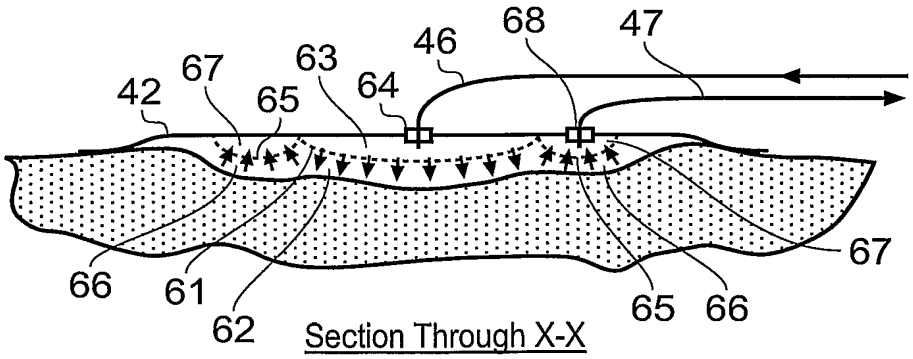
X

Fig. 4a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Section Through X-X

Fig. 4b

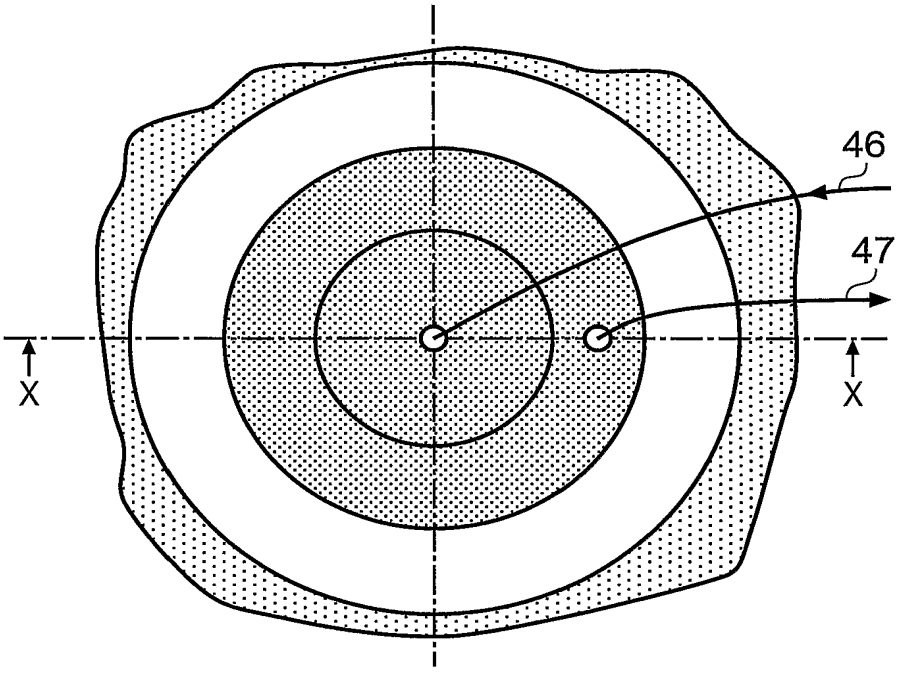
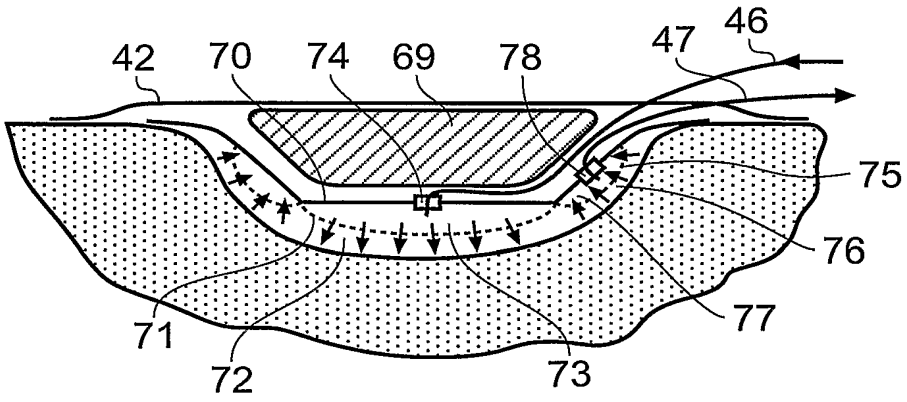


Fig. 5a



Section Through X-X

Fig. 5b

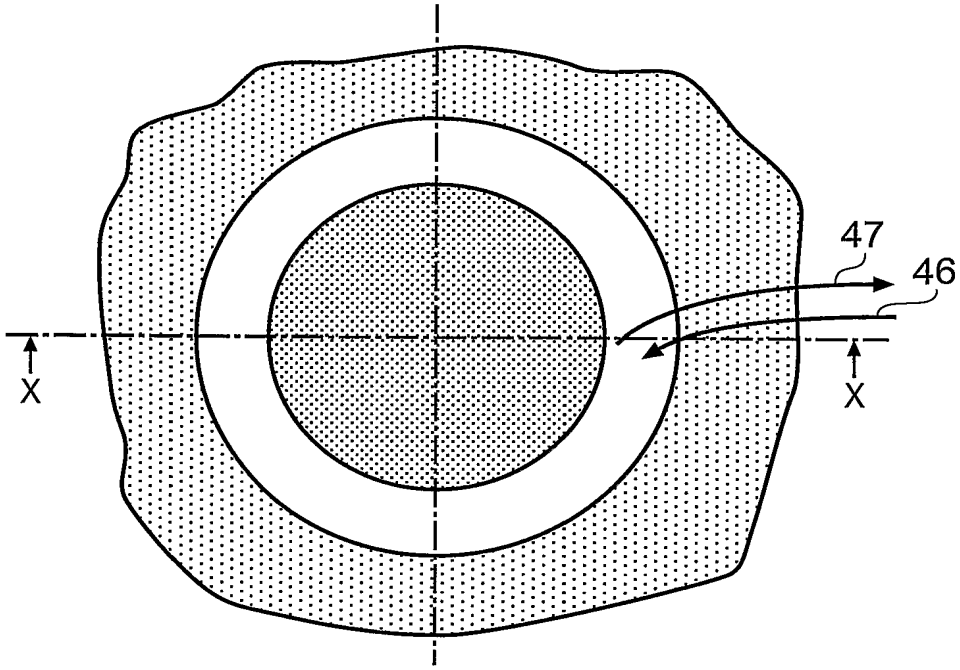
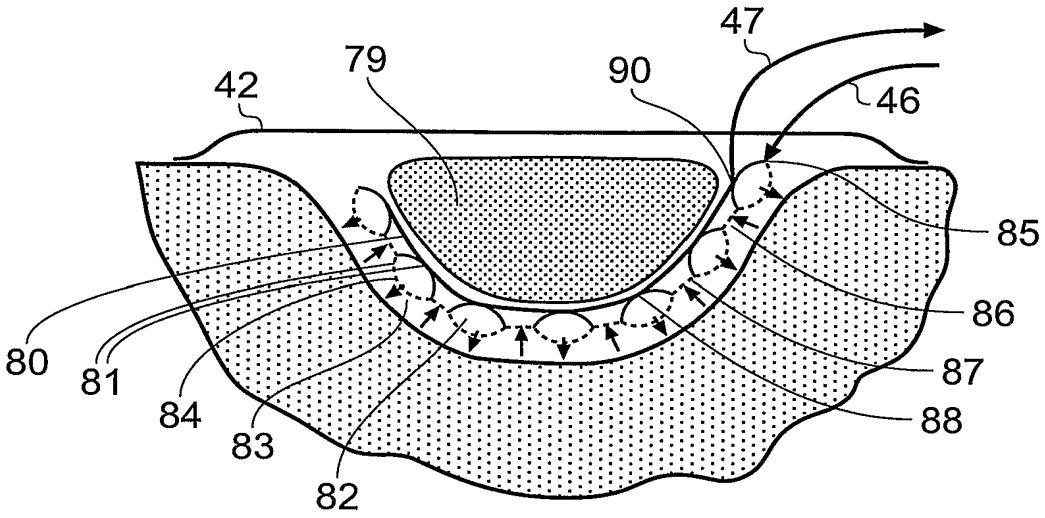


Fig. 6a



Section Through X-X

Fig. 6b

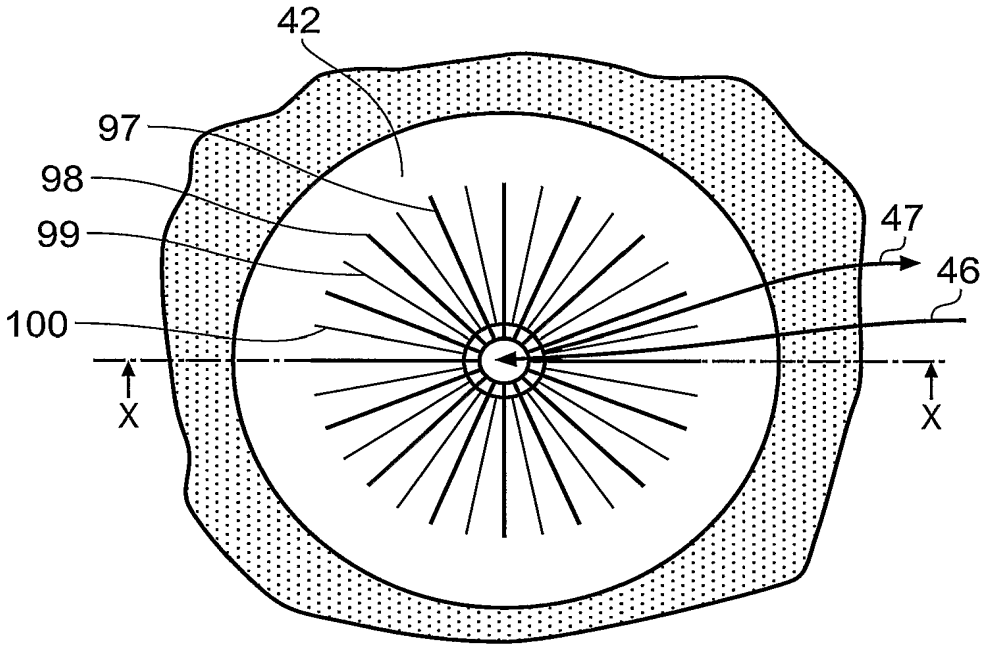
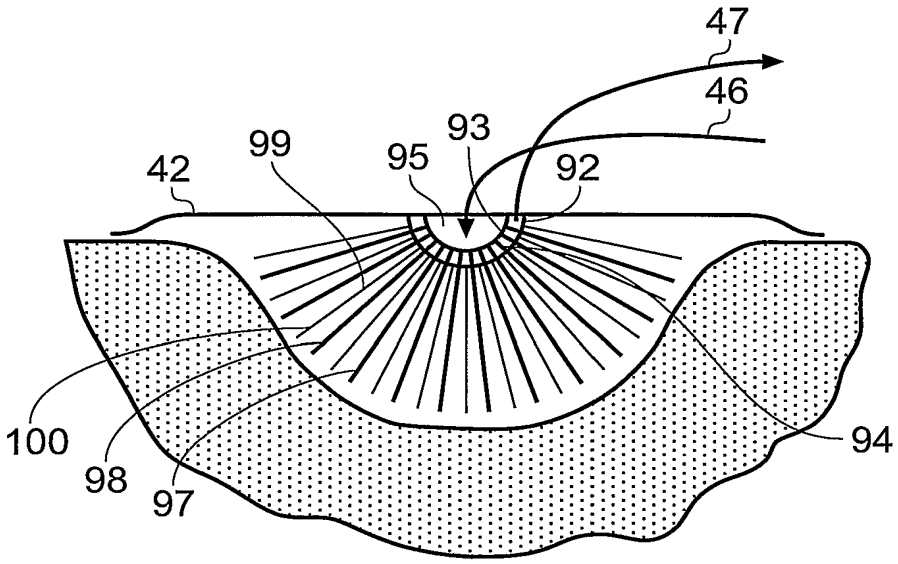


Fig. 7a



Section Through X-X

Fig. 7b

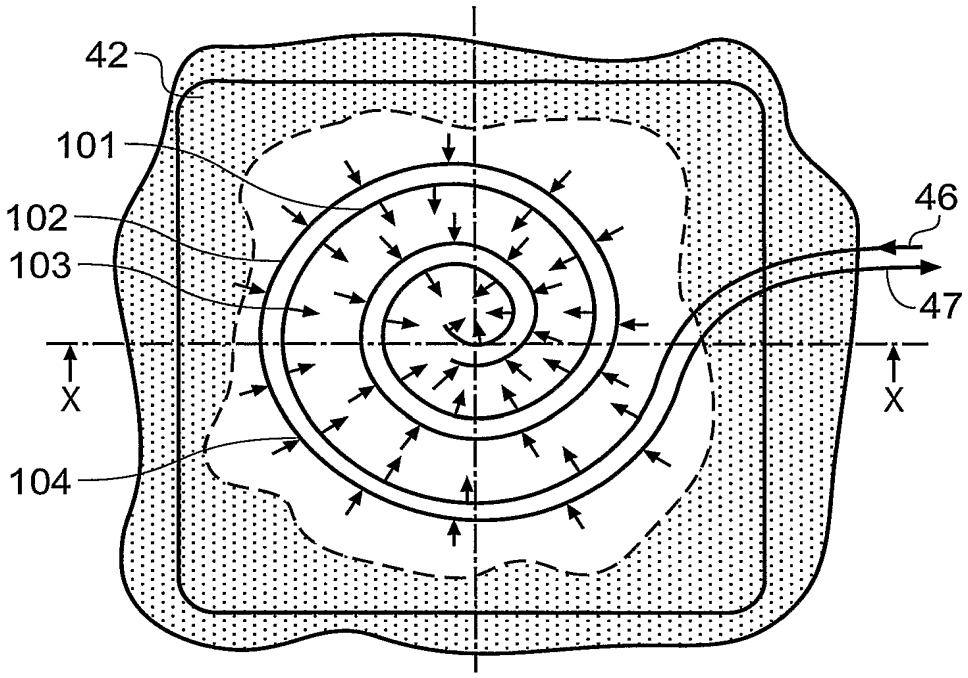


Fig. 8a

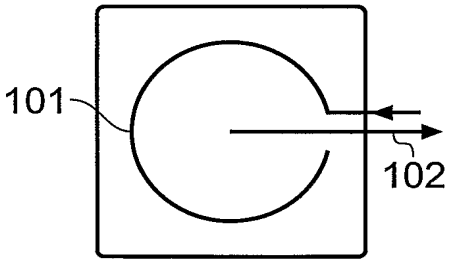


Fig. 8b

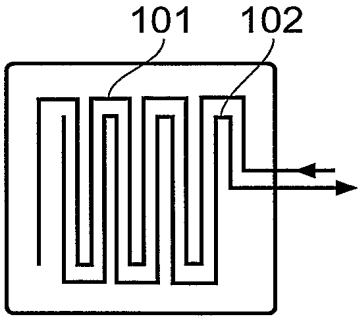
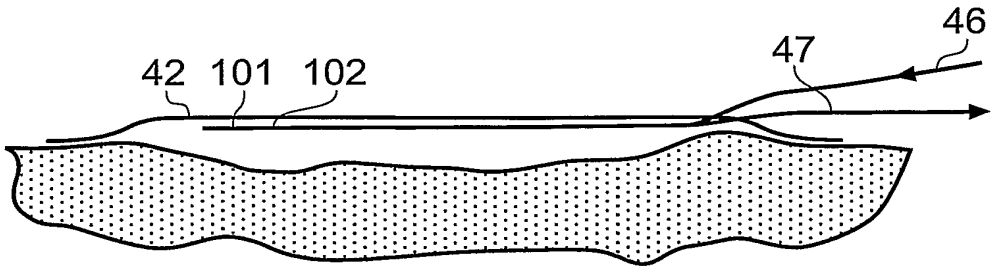


Fig. 8c



Section Through X-X

Fig. 8d

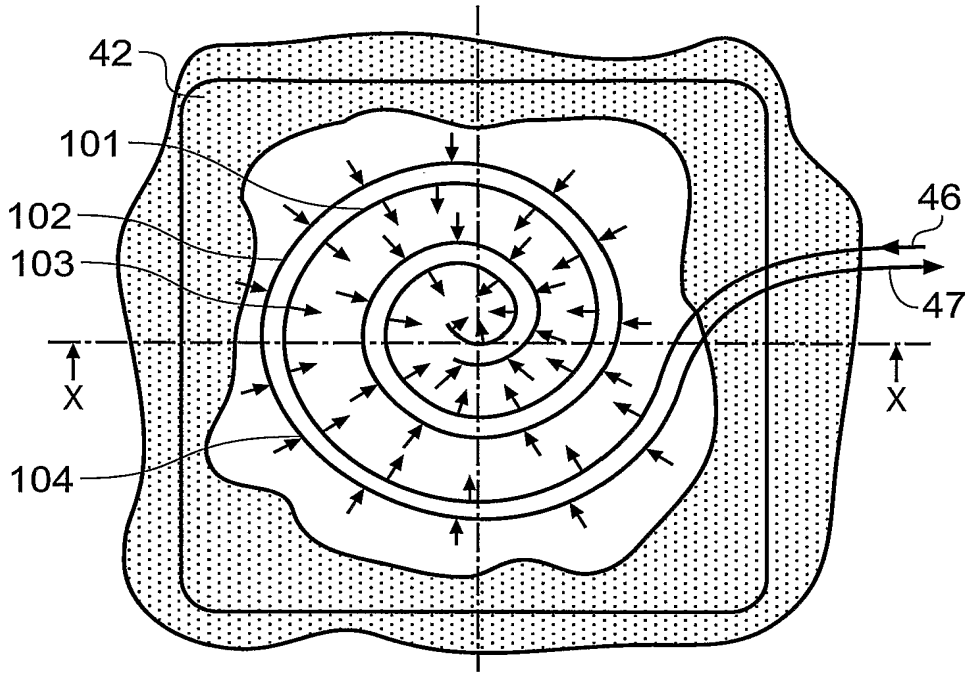
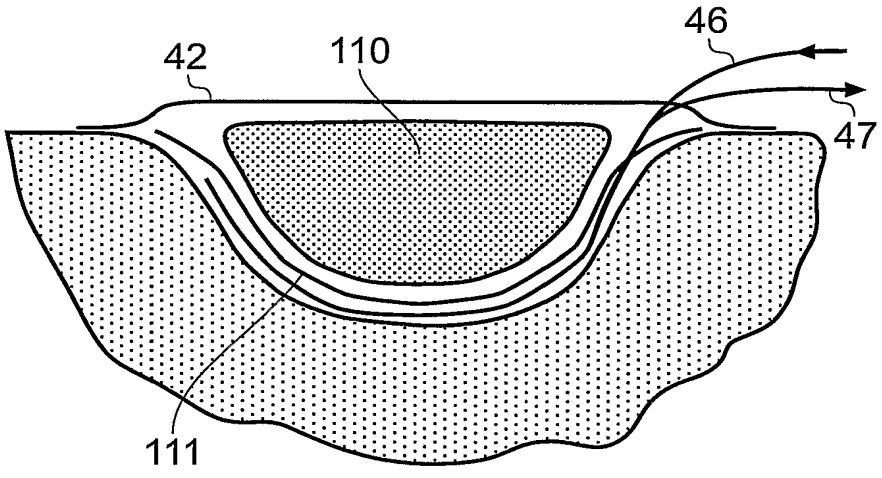


Fig. 9a



Section Through X-X

Fig. 9b

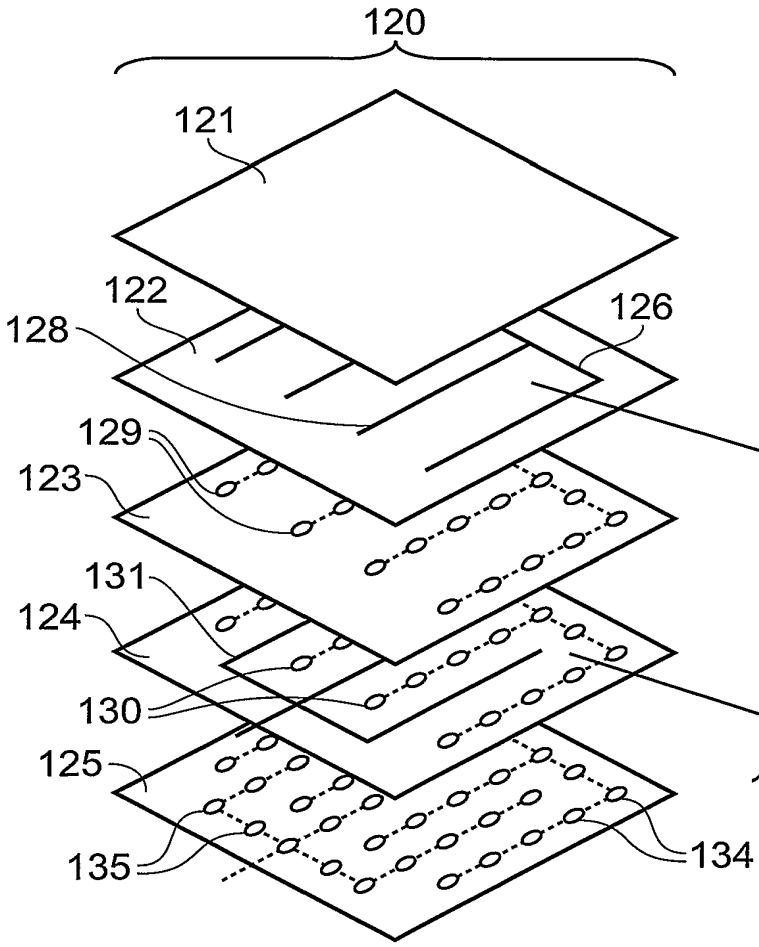


Fig. 10a

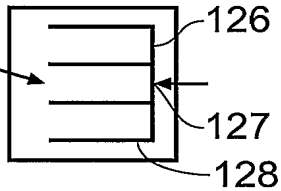


Fig. 10b

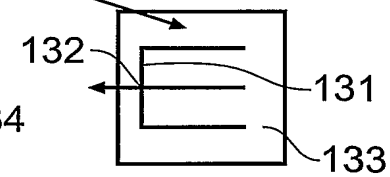


Fig. 10c

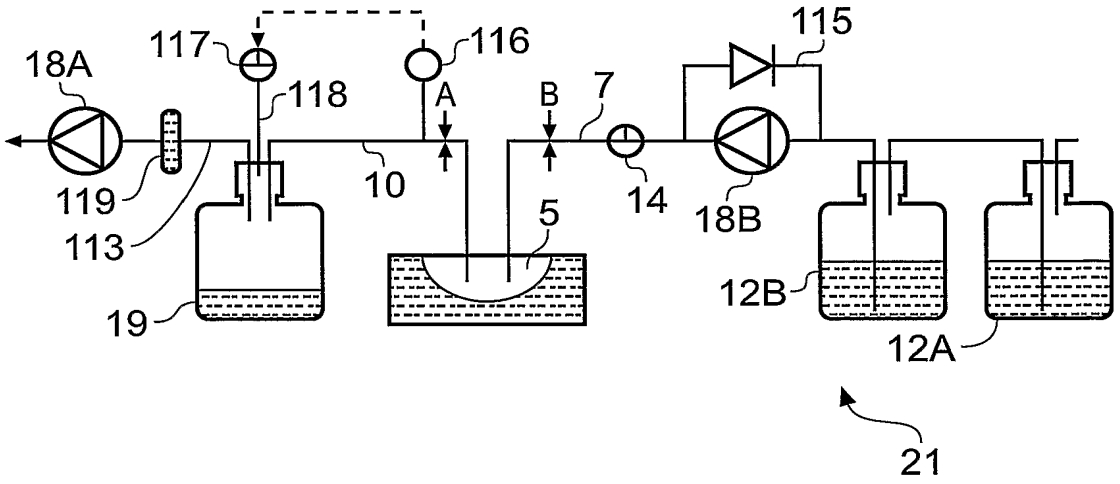


Fig. 11a

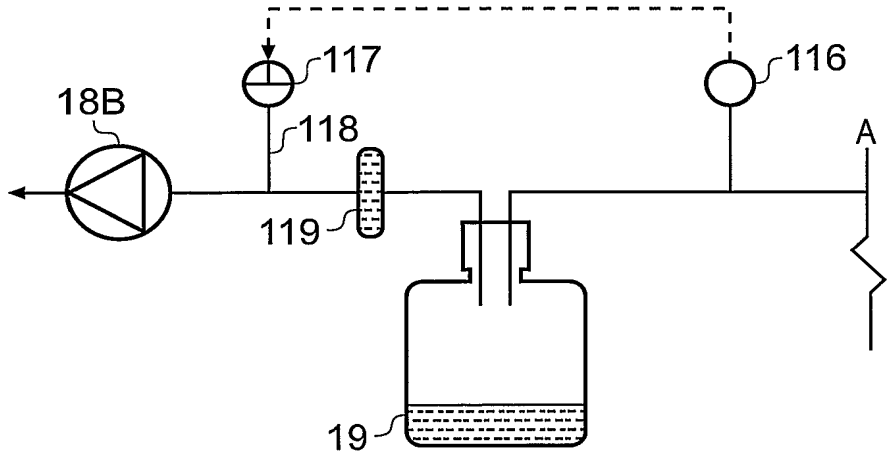


Fig. 11b

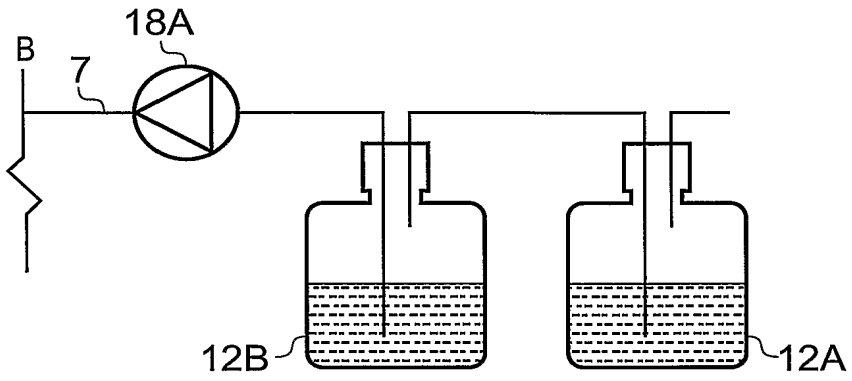


Fig. 11c

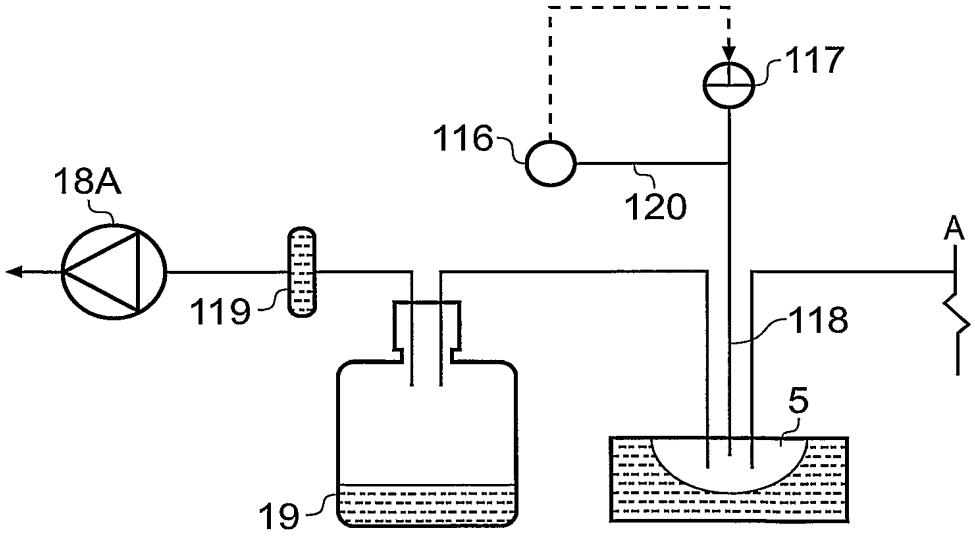


Fig. 11d

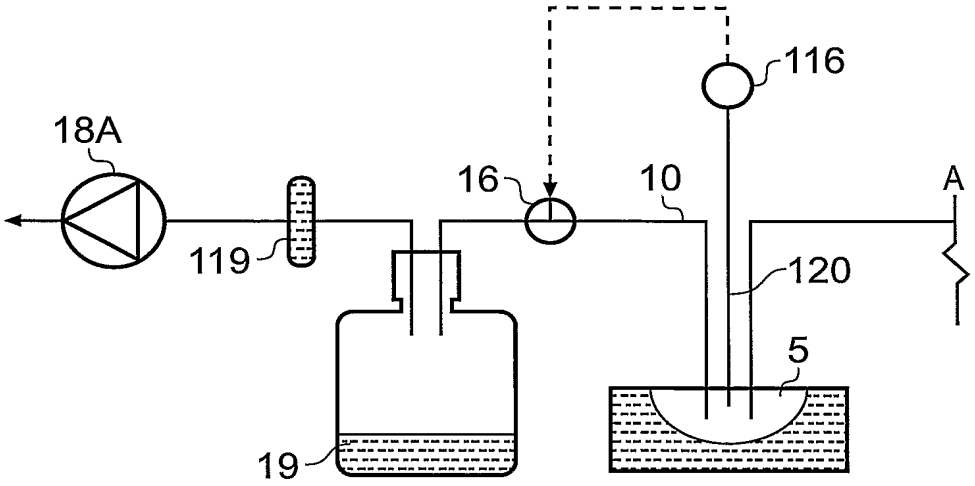


Fig. 12a

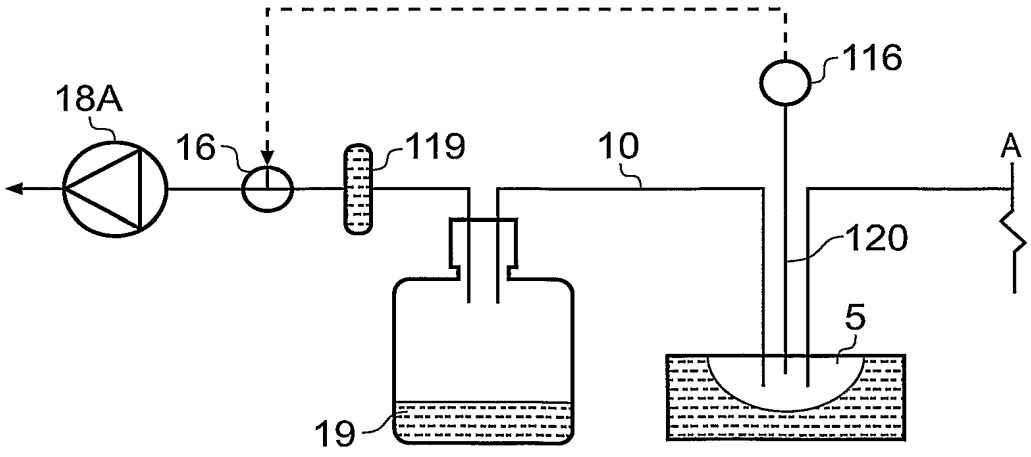


Fig. 12b

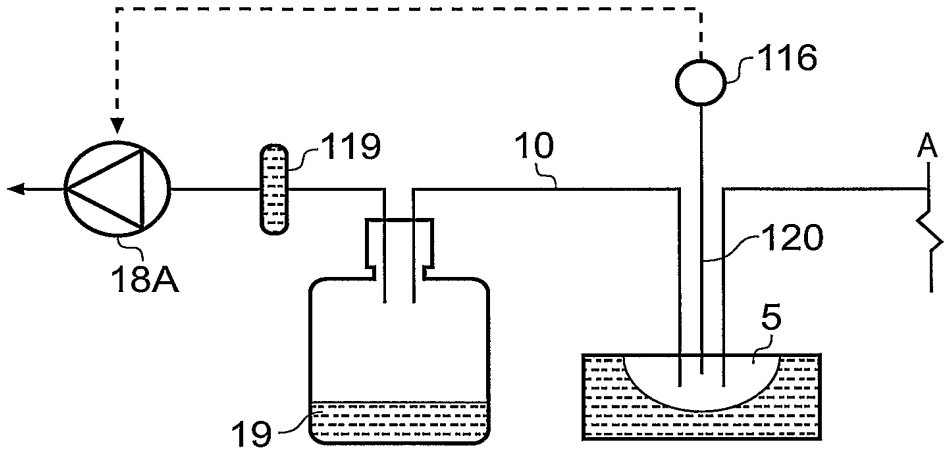


Fig. 12c

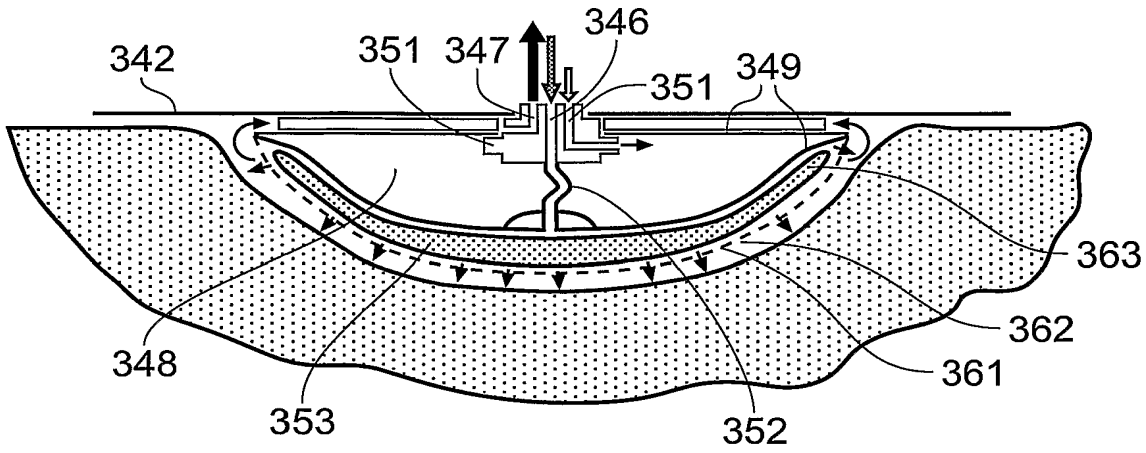


Fig. 13a

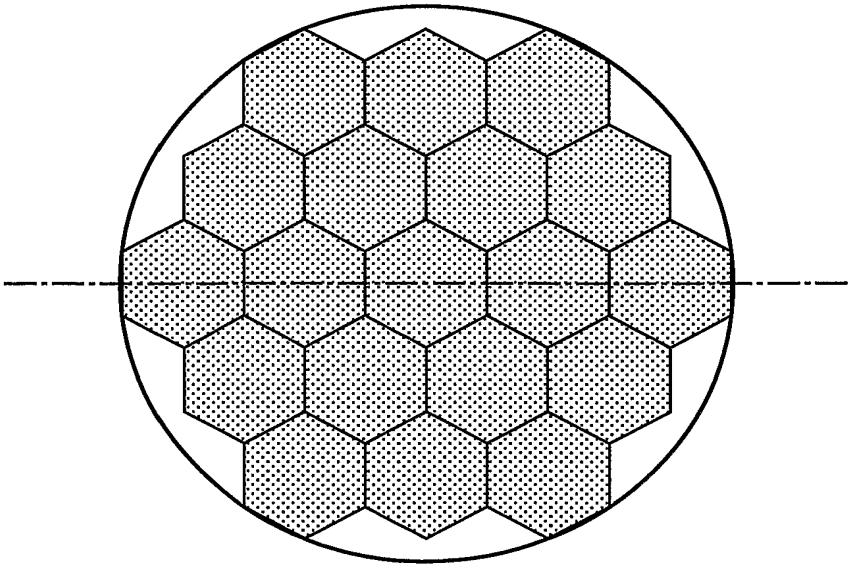


Fig. 13b

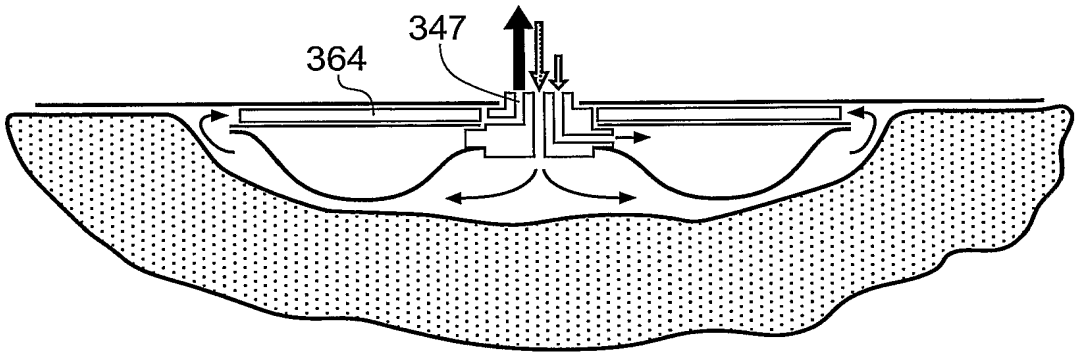


Fig. 14

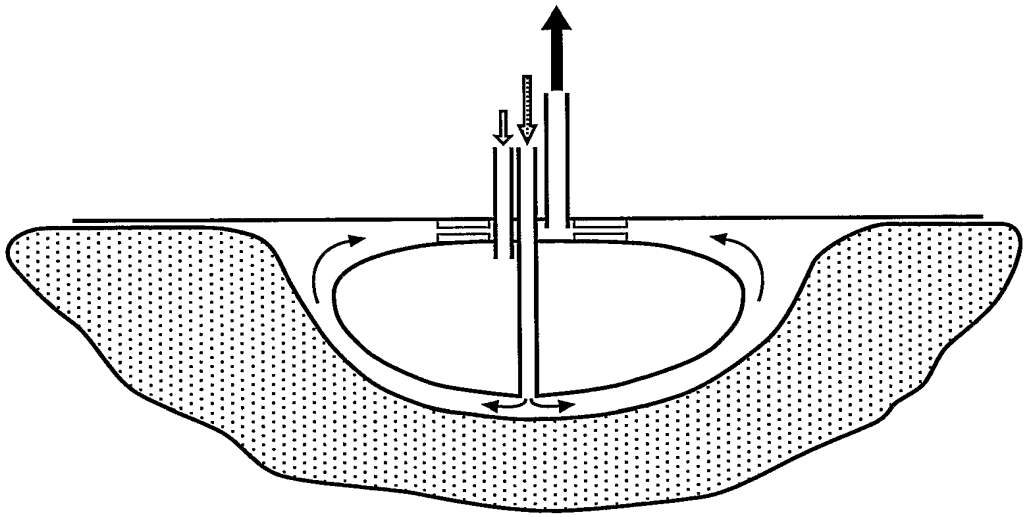


Fig. 15

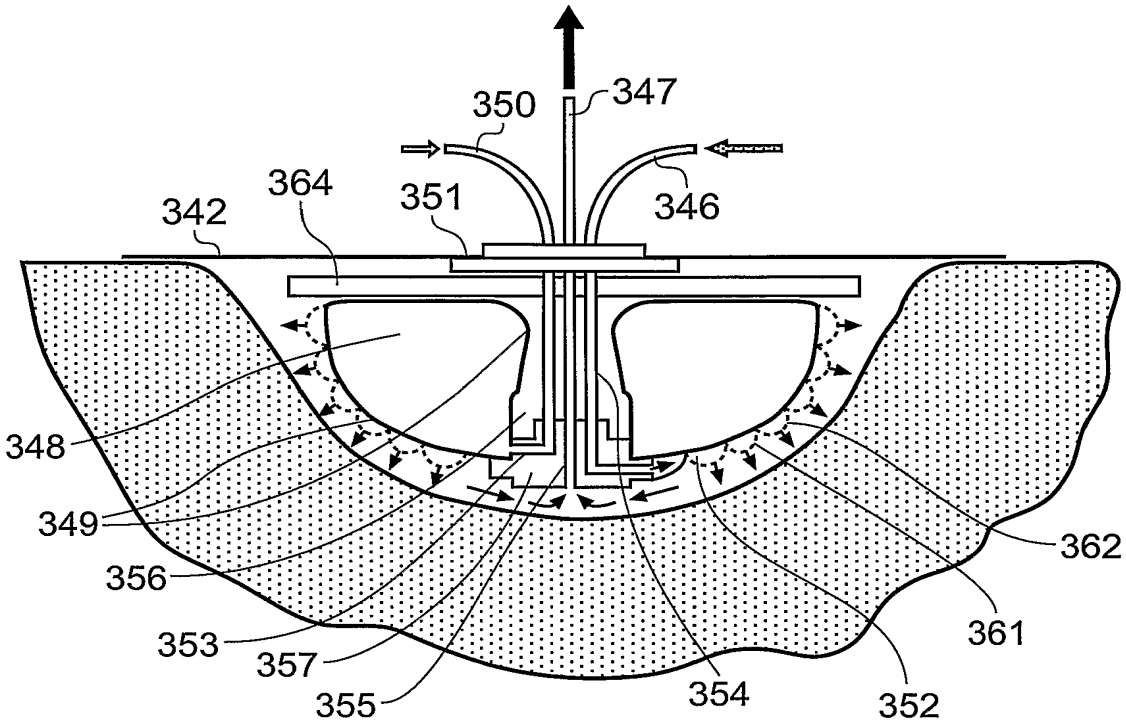


Fig. 16a

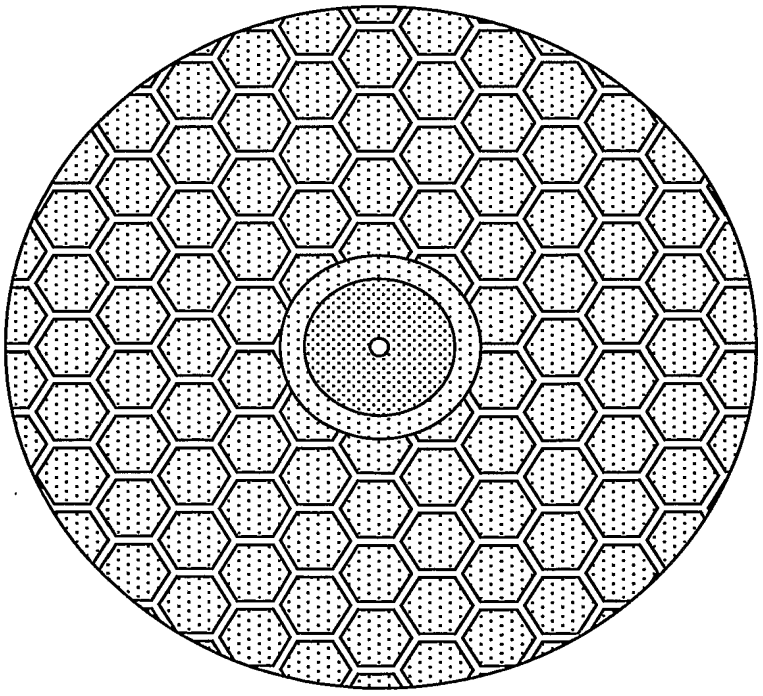


Fig. 16b

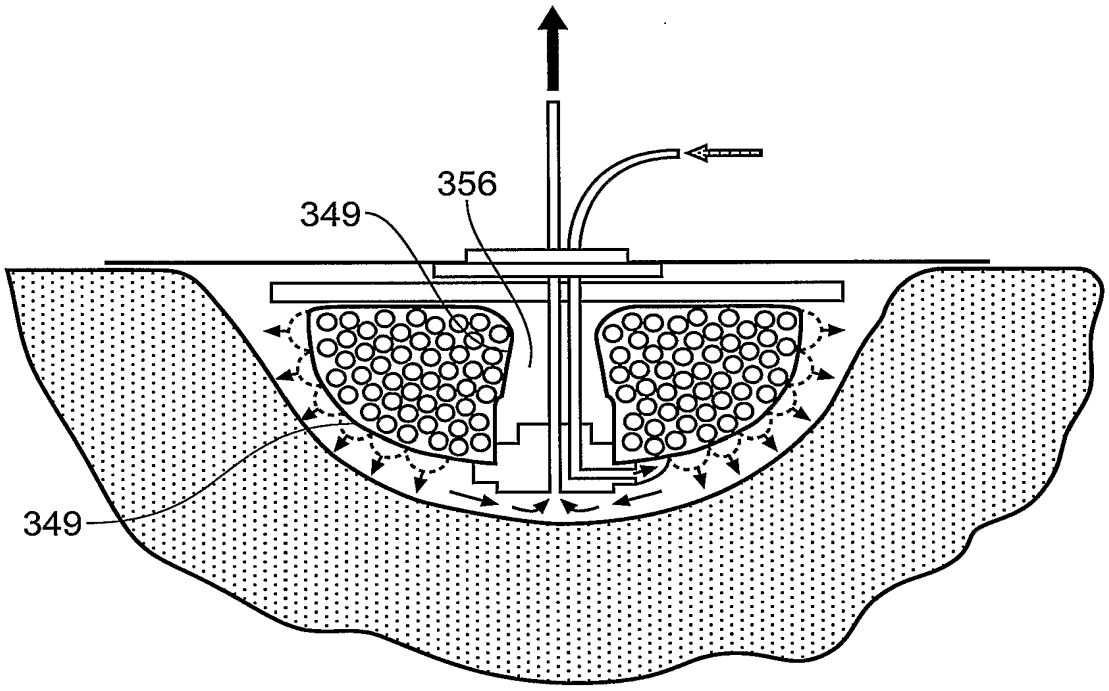


Fig. 17

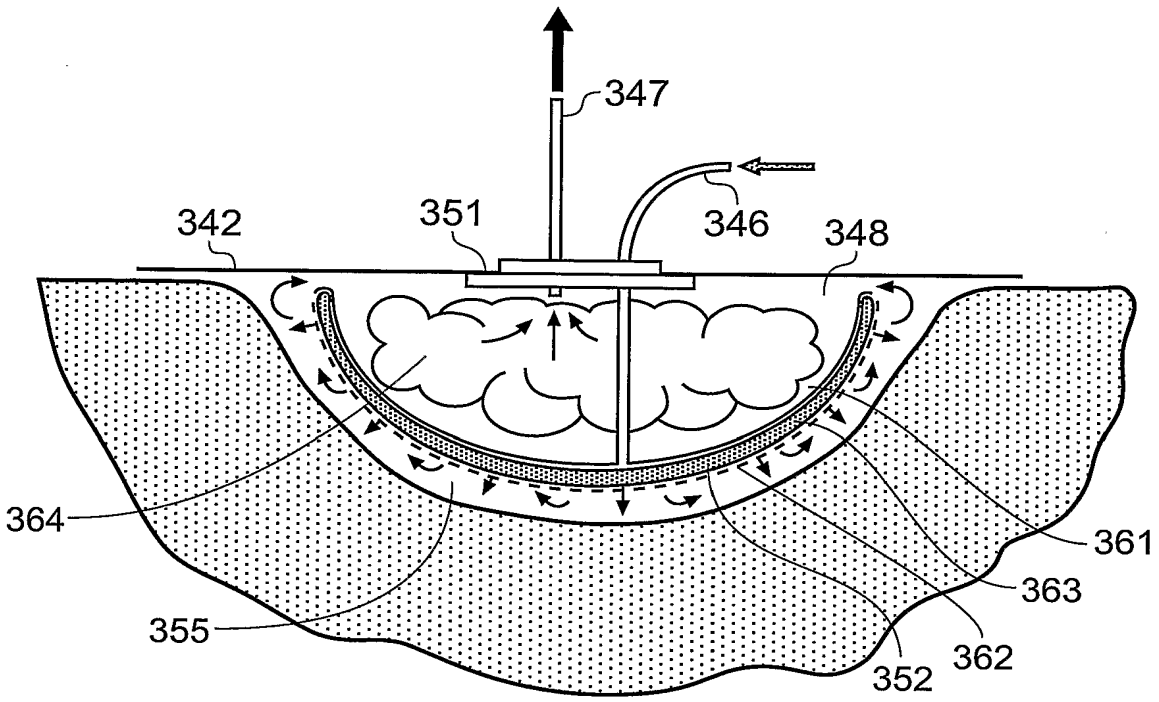


Fig. 18a

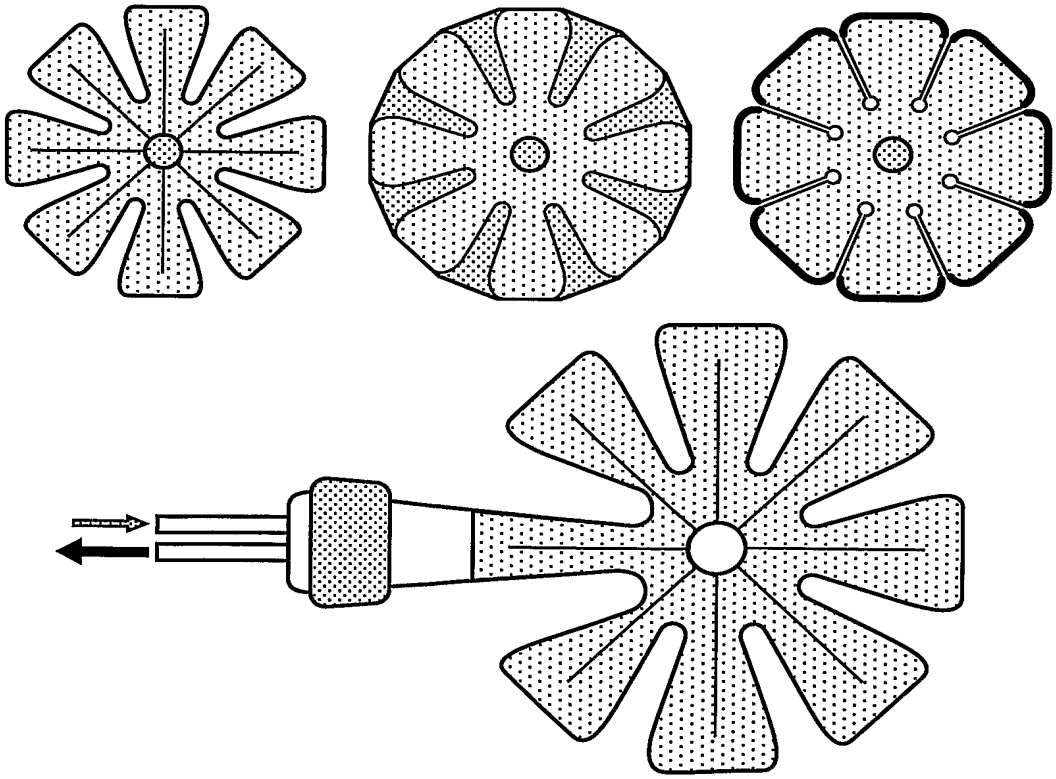


Fig. 18b

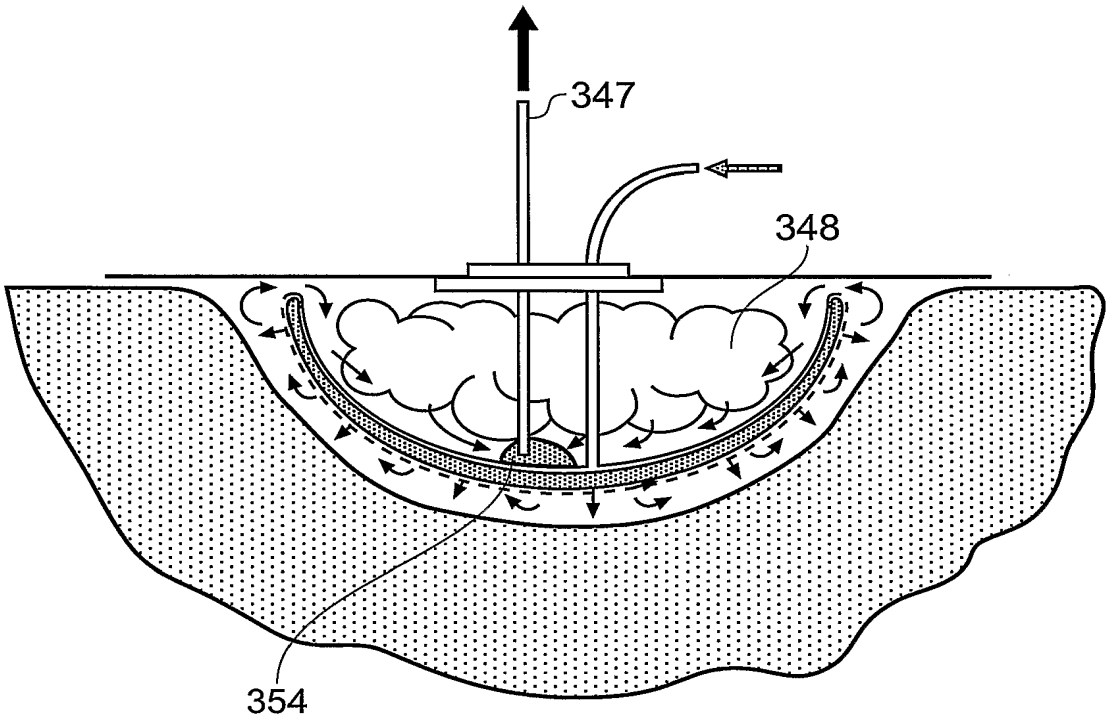


Fig. 19

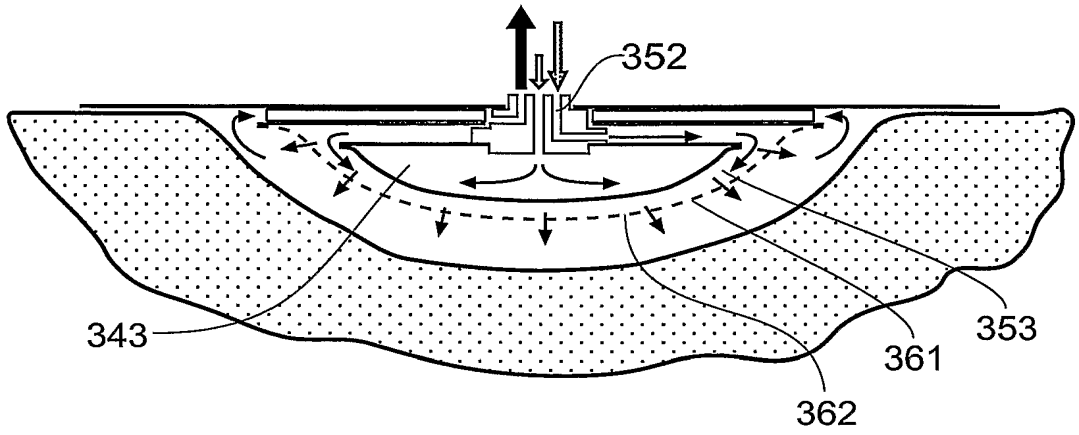


Fig. 20

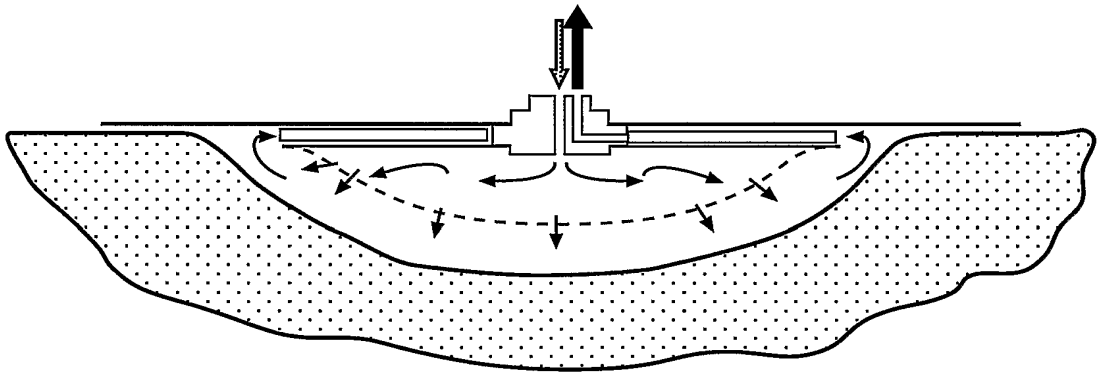


Fig. 21

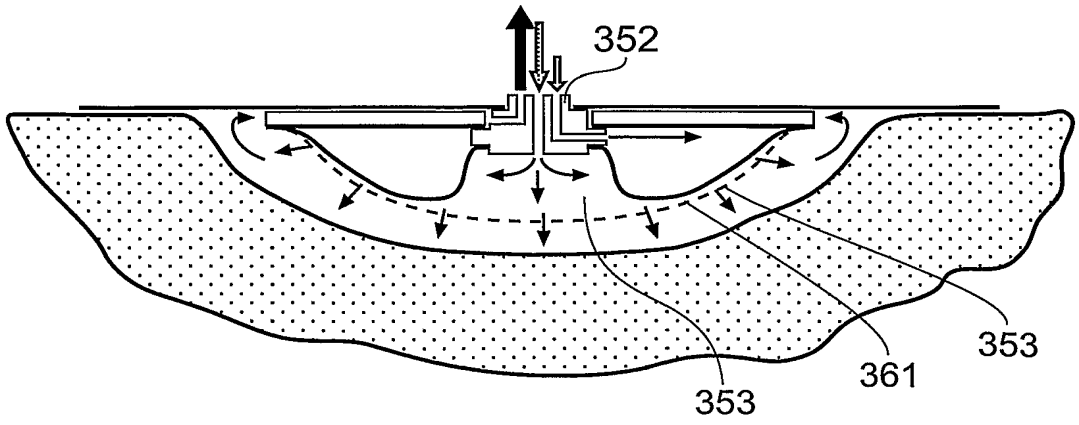


Fig. 22

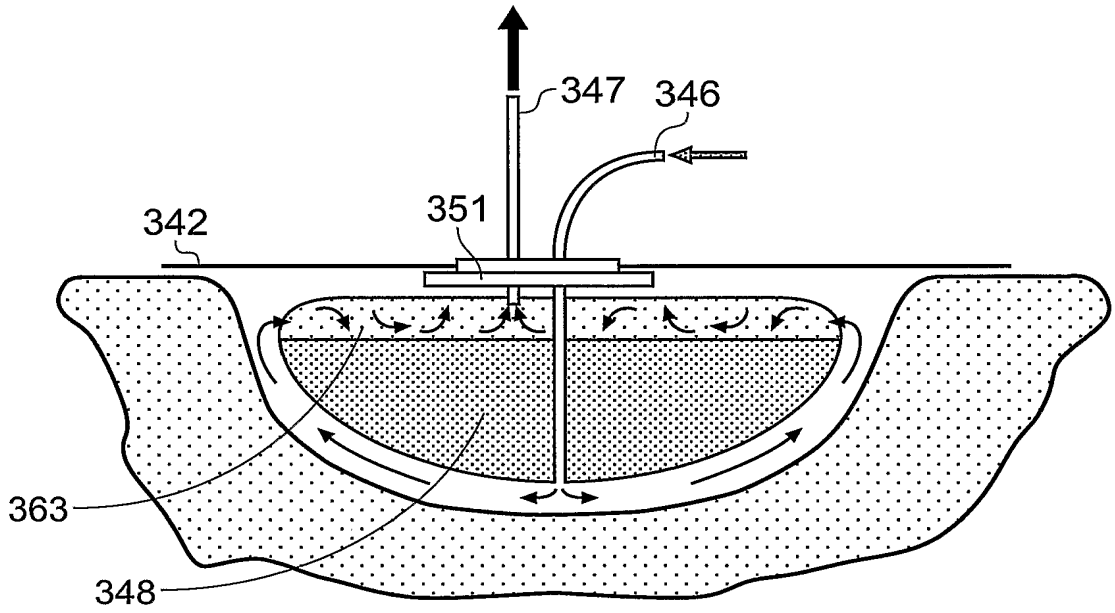


Fig. 23

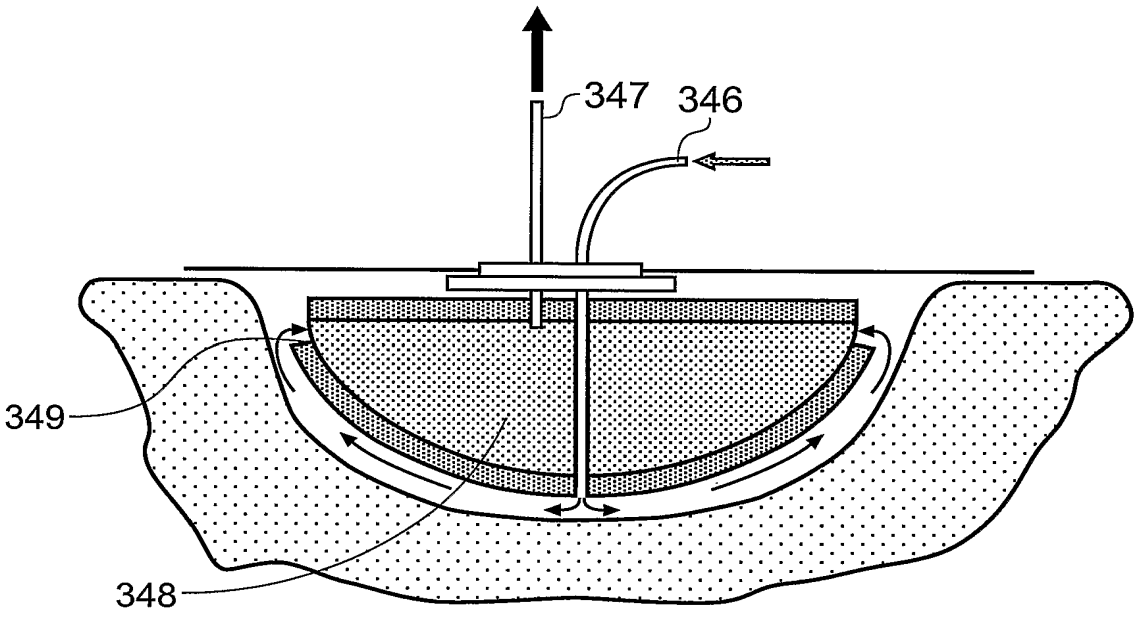


Fig. 24

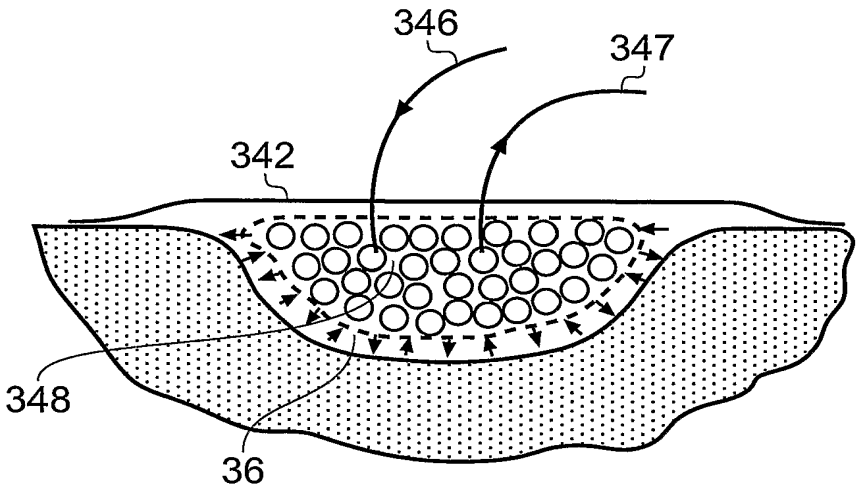


Fig. 25

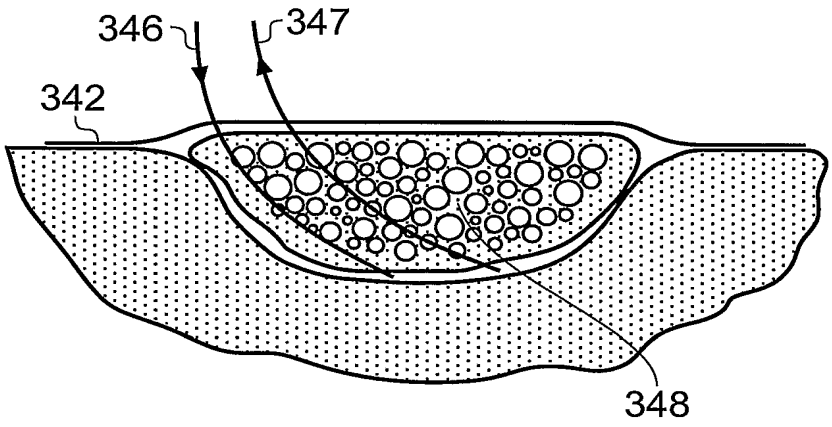


Fig. 26

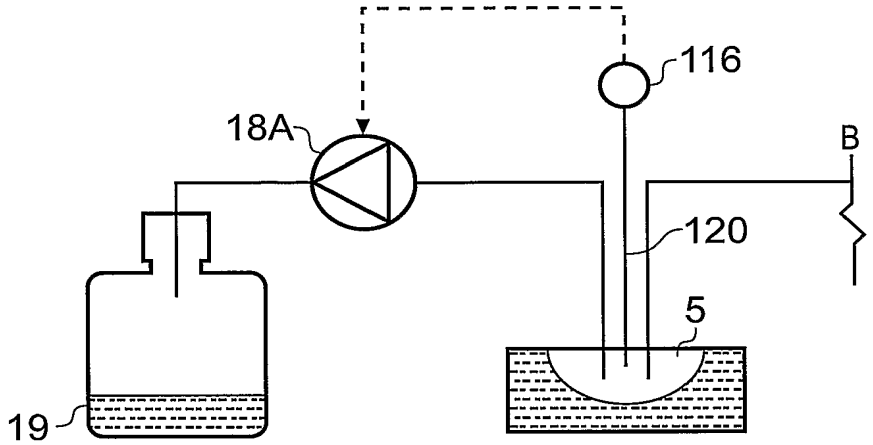


Fig. 27a

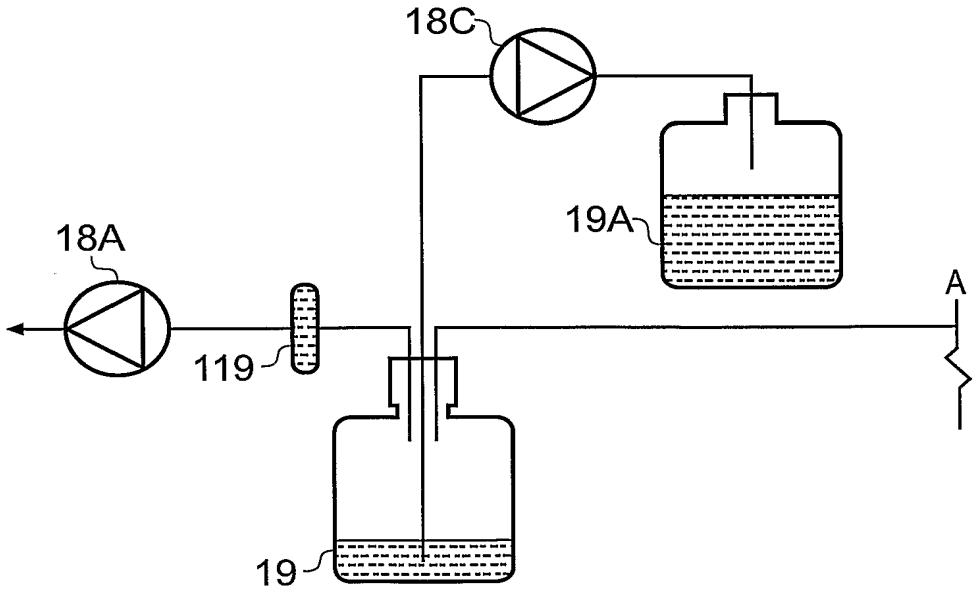


Fig. 27b

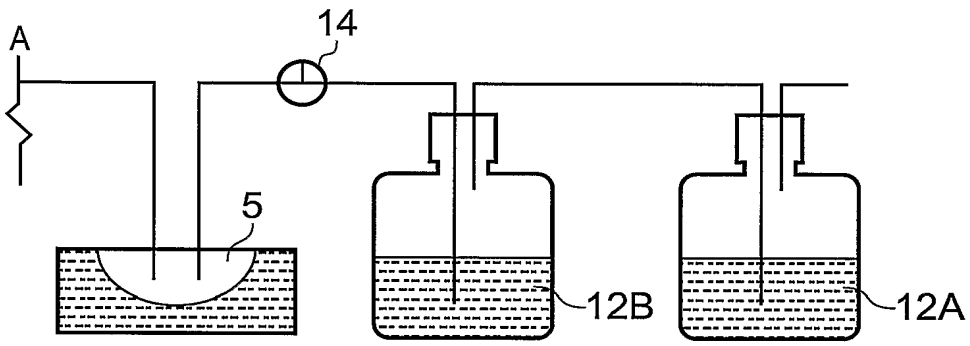


Fig. 28

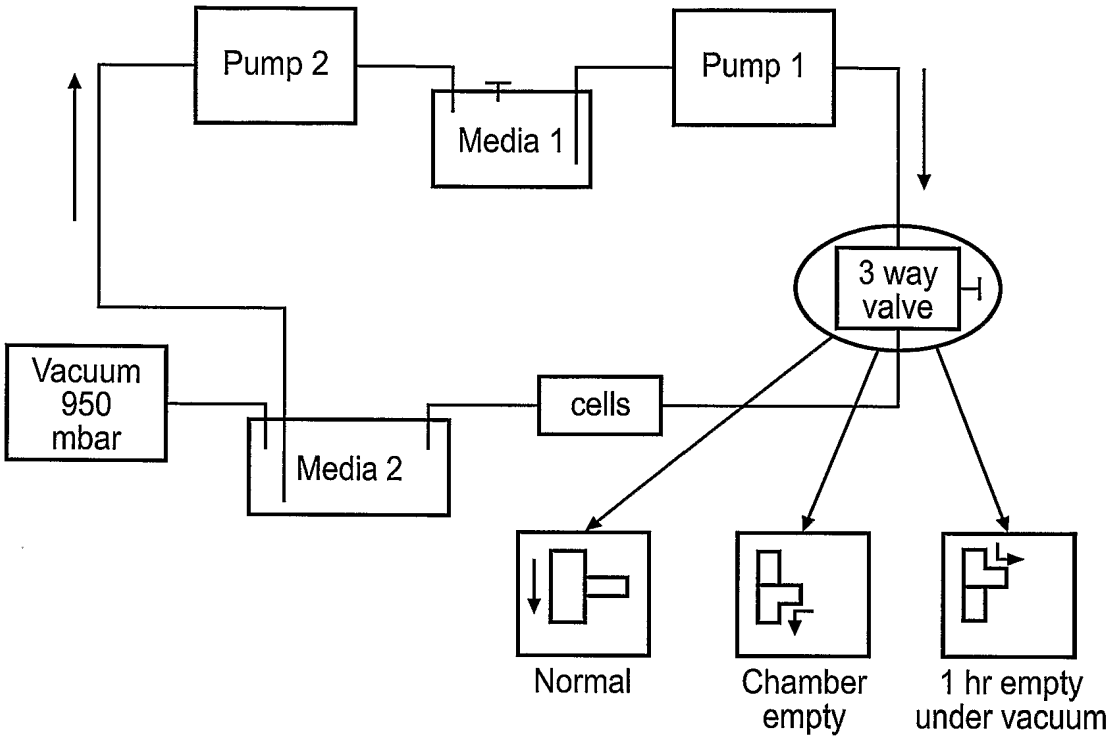

Pump 2
Media 1
Pump 1
3 way valve
Vacuum 950 mbar
Media 2
cells
Normal
Chamber empty
1 hr empty under vacuum

Fig. 29

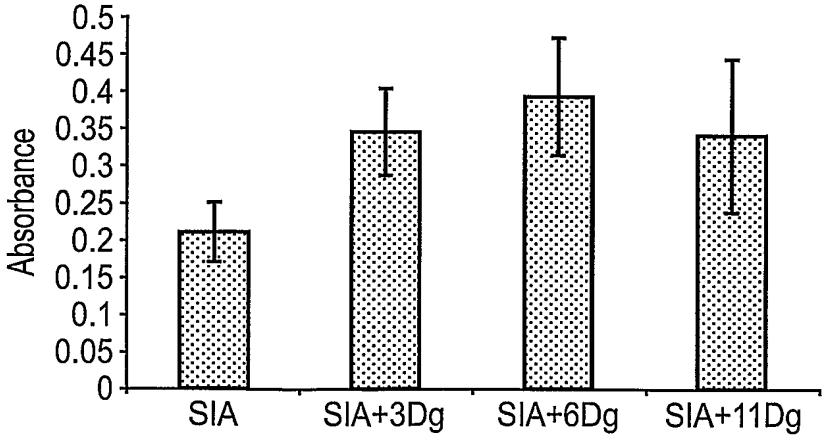

Absorbance
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
SIA
SIA+3Dg
SIA+6Dg
SIA+11Dg

Fig. 30

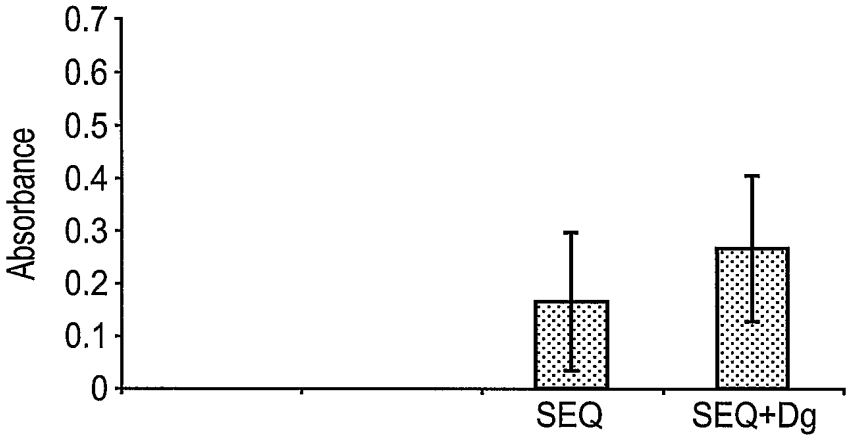


Fig. 31

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/003421

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61M1/00 A61M3/02 A61M27/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2005/046761 A (SMITH & NEPHEW [GB]; BLOTT PATRICK LEWIS [GB]; GREENER BRYAN [GB]; HAR) 26 May 2005 (2005-05-26) The whole document and especially: page 6, paragraph 3; claim 1; figure 1	1-24
X	WO 2005/070480 A (UNIV RAMOT [IL]; ENZYSURGE LTD [IL]; FREEMAN AMIHAY [IL]; HIRSZOWICZ E) 4 August 2005 (2005-08-04) page 19, line 25 - page 20, line 30; figures 2,3 page 22, line 10 - line 12	1-24
X	WO 02/092783 A2 (CHILDRENS MEDICAL CENTER [US]) 21 November 2002 (2002-11-21) paragraph [0062]; figure 9	1-24

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 February 2007	20/02/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lakkis, Angeliki

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2006/003421

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 25
because they relate to subject matter not required to be searched by this Authority, namely:

Rule 39.1(iv) PCT - Method for treatment of the human or animal body by therapy

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2006/003421

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2005046761 A	26-05-2005	AU 2004289091 A1	26-05-2005
		CA 2543356 A1	26-05-2005
		CN 1874801 A	06-12-2006
		EP 1677851 A1	12-07-2006
		KR 20060102334 A	27-09-2006
WO 2005070480 A	04-08-2005	AU 2005205996 A1	04-08-2005
		CA 2554330 A1	04-08-2005
		EP 1720586 A1	15-11-2006
WO 02092783 A2	21-11-2002	US 2003108587 A1	12-06-2003